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A LUMP OF CHALK AND ITS LESSONS.

By R. LYDEKKER, B.A.Cantab.

PROBABLY all Englishmen—certainly all those dwelling in the eastern and south-eastern counties—are familiar with the pure white rock which we call, from the Latin *creta*, Chalk. It is indeed this very familiarity which breeds the proverbial contempt, and causes us to take but scant or little notice of what is really a very beautiful substance in itself, altogether apart from the interest with which it is invested from a geological point of view. If Chalk were very rare instead of being exceedingly abundant, there is little doubt that it would be reckoned as a beautiful substance, worthy to stand as the best example of a pure white mineral alongside of virgin sulphur as the finest sample of a yellow one. If, moreover, Chalk had happened to have undergone the action of intense heat under equally intense pressure, it would assuredly have produced an even finer and purer statuary marble than that of Carrara, and might thus have been one of the most valuable of rocks.

A complaint may not unfrequently be heard among those more or less deeply interested in geological science who happen to dwell in a Chalk district, that the very sameness of the Chalk formation throughout England prevents them from finding any interest in the geology of their own districts, and thus leads them to regret that their lot had not been cast in regions where a variety of rocks are to be met with. Although there is a considerable amount of truth in this complaint, yet if rightly studied the Chalk is so peculiar and unique a formation as rather to embarrass us with the number of considerations and problems to which it gives rise, than to be deficient in interest.

Examining a lump of the pure white Chalk of many parts of England, such as that of Dover, we find that it consists, both to the naked eye and under an ordinary lens, of an exceedingly fine-grained homogeneous soft substance, adhering strongly when applied to the tongue, and leaving a white streak when rubbed on other substances. If treated with vinegar, or any other acid, it will effervesce strongly with the liberation of the gas commonly known as choke-damp, or carbonic acid, while the base unites with the new acid to form a fresh compound of lime. The lime may be obtained in a pure condition by burning the Chalk, as in a lime-kiln, when the carbonic acid is likewise given off; and we thus learn that Chalk consists of carbonate of lime. As a rule, when we examine a Chalk-cliff we shall find that the Chalk, although stained here and there with iron, is identical in structure throughout great thicknesses, and that it shows nowhere any signs of crystallization. Occasionally, however, as at Corfe Castle, near Swanage, in Dorsetshire, we shall find that the Chalk has become so hard as to leave no distinct streak when rubbed lightly on other substances; while its cracks and fissures are filled with translucent crystals of white spar—the calc-spar, or calcite of mineralogists. Here then we have the Chalk so hardened, probably by the effects of subterranean heat, as to form what is popularly called a limestone; while a farther step would have converted it into actual marble. The geologists would indeed apply the name limestone to Chalk, ordinary limestone, and marble indifferently; but since the popular usage is different, it is well to be assured that all three are but various modifications of one and the same substance. In the north of Ireland the basalt of the Giant's Causeway has converted the Chalk still more completely into a hard limestone.

Chalk, then, may be defined as a fine-grained, white, non-crystalline, soft limestone. This, however, by no means exhausts the subject of its composition. Thus if we take a piece of Chalk and wash it carefully in water with a hard brush so as to reduce it to a state of mud, and examine the portion which falls to the bottom of the vessel under a microscope, we shall find that this is very largely made up of various shell-like substances. Many of these are minute fragments of what may have been real shells, while others are portions of the spines of sea-urchins, and others, again, are the flinty spicules of sponges. By far the larger proportion consists, however, of perfect objects of extremely minute size, mainly belonging to that lovely group of animals known as foraminifers, or shortly, "forams." Of these beautiful little shells some are coiled in a manner recalling the shell of the nautilus, while others consist of globular masses arranged either in a coil or in a straight line, the globules gradually increasing in size from the summit to the mouth of the shell. In all cases, however, the walls of these shells are perforated by the inconceivably minute apertures from which the forams take their name, and through which, when alive, the creatures protruded delicate threads of the jelly-like protoplasm of which their soft parts are composed. Truly marvellous in beauty are these forams, although pages of description can give but a faint idea of them, and the student should see them for himself under a microscope. So numerous, moreover, are these forams, and other equally minute organisms in the white Chalk, that they frequently compose half its substance, while it is

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stated that in some rare cases they may even rise to as much as ninety per cent.

We have now, therefore, to add to our definition of Chalk that it is largely composed of the shells of the minute animals known as forams, together with those of other allied creatures, and so may accordingly speak of it as a limestone which is evidently to a large extent of organic origin. Moreover, as these forams are more or less closely allied to species inhabiting the ocean at the present day, we should be justified from this evidence alone in regarding the Chalk as a formation of marine origin. This origin is, however, equally well proved by the larger fossils, such as shells of sea-urchins, scallops, oysters, etc., commonly occurring in the Chalk; while, in addition to this, the extreme purity and thickness of the formation would of itself be sufficient to demonstrate that the Chalk is the result of long-continued deposition on the bottom of the sea.

Thus much for the composition of our lump of Chalk as examined in the laboratory, and we now turn, as all geologists worthy of the name should, to its occurrence in the field. If we look at one of the tall Chalk cliffs of our southern coasts, as in the neighbourhood of Dover, we shall be first of all struck with the extreme homogeneity and purity of the whole formation from top to bottom, through a thickness which in this neighbourhood is close upon 1000 feet, and in Norfolk is more than 1100 feet. This similarity of composition throughout such a vast thickness is totally unlike what we are accustomed to observe in other rock-cliffs (although there is some approach to it in the blue mountain-limestone of Derbyshire), where we generally find alternating bands composed of rocks differing both in colour and structure from one another, and we are thereby led at once to conclude that there must be something very peculiar connected with the deposition of the Chalk. How was it that in the old sea there were not only no currents bringing loads of sand or clay to alternate with the pure white limestone, but, above all, that there was not a tinge of colouring matter to stain the virgin purity of the newly-forming Chalk during those ages and ages of time, while drifted logs and fruits occur but rarely?

A closer inspection of a large thickness of Chalk will, however, reveal the fact that there is not a complete similarity in the nature of the rock throughout the entire formation. Thus, whereas in places where nearly the whole formation is displayed we find throughout the uppermost 400 feet layers and nodules of flint are thickly distributed throughout the mass, generally forming more or less well-marked lines which indicate the original planes of the deposition of the rock, as we pass to a lower level the proportion of these flints becomes gradually less, till, after we have passed downwards through some 130 feet, they finally disappear, and are wanting throughout the whole of the lower part of the series. Moreover, in this lower Chalk, or Chalk without flints, we shall find, as we pass downwards, a gradual tendency to lose the pure white colour of the upper Chalk, and to assume a buff or greyish tint, while in the very lowest beds we shall not fail to notice the appearance of a number of small grains of a greenish-coloured mineral. If, again, we try to dissolve this lower Chalk in acid we shall find that as we descend in the series there is an ever increasing quantity of an insoluble remnant, which would be shown by analysis to be of the nature of clay. Both these circumstances point to the conclusion that at the time the lower Chalk was laid down the conditions were by no means so well adapted for the deposition of a pure carbonate of lime as was the case in the later time of the upper Chalk with flints. What these conditions were we shall consider subsequently, but we have now to direct our attention to the area over which the white Chalk extends.

In the north-west the furthest limits to which the white Chalk extended are found near Belfast, where, as we have said, the rock has been converted into a hard limestone by the action of heat. Although we do not again meet with Chalk till we reach the east and south of England, where it forms large portions of our coast from Dorsetshire to Yorkshire, yet it is probable that the Chalk sea embraced the foot of the Welsh mountains, which formed an archipelago. From England the white Chalk may be traced without any alteration in its character through the north of France, the south of Belgium, the eastern part of the Netherlands, and thence through Westphalia, Hanover, and Galicia, into Poland and Russia, where it reaches on the one side to the foot of the Urals, and on the other to the Crimea; moreover, to the northward it occupies a considerable portion of Denmark and the southern extremity of Sweden. Although the white Chalk is now only distributed over the surface of this region in larger or smaller patches, being sometimes covered up by newer (Tertiary) deposits, and in other places totally wanting, there is evidence that it once extended continuously over the whole. Moreover, the absence of any traces of the white Chalk in the regions to the west and north of those mentioned, indicates that the present limits of the Chalk in those directions mark approximately the boundaries of this cretaceous sea; this sea being probably cut off from free communication with the Atlantic by a barrier connecting western France with Cornwall and Ireland, and by another joining Scotland with Scandinavia.

The above area includes the whole of the white Chalk; but when we trace this Chalk southwards into Bohemia and Saxony we find that it has undergone a very remarkable change. Thus, although it contains the same fossils as to the northward, the rock itself, instead of being the pure white limestone to which we have been accustomed, consists of a series of massive sandstones about as unlike Chalk as anything well could be. It is probable, indeed, that these cretaceous sandstones, as we may call them, were formed in a gulf on the southern coast of the white Chalk sea, which was unfavourable to the deposition of Chalk itself; and as these sandstones were undoubtedly deposited at the same time as the pure Chalk, we thereby learn the very important geological lesson that similarity or dissimilarity in the mineralogical structure of a rock is a matter of very minor import indeed. We may illustrate this by reference to architecture. Thus, a Gothic church may be built either of sandstone, limestone, marble, or, for the matter of that, brick; but it will still be (exclusive of course of our so-called modern Gothic) absolutely characteristic of one particular period of European architecture. This Gothic style will be distinguished by certain peculiarities in the structure of its arches and pillars, as well as by the ornaments with which they are embellished. Just so in geology we have a Chalk or cretaceous style, in which, although the rock itself may be either Chalk or sandstone, or limestone, or slate, yet its architectural details—that is to say, its fossils—will be the same, not only throughout Europe, but within certain limitations of variation, over the whole world. This is one of the important lessons to be learnt by a comprehensive study of our white Chalk.

The second great lesson taught by the white Chalk is, however, of perhaps still more importance. We have seen that the white Chalk was deposited in a sea cut off from free communication with the Atlantic to the west and north; and the range of the Ardennes which formed its

shore in the south-west, together with the evidence of the near neighbourhood of a coast afforded by the sandstones of Saxony and Bohemia, indicates that this sea was a *mare clausum* (in a geographical, not a political sense), somewhat like the Mediterranean or the Black Sea. Now, from the apparent similarity of Chalk to the ooze forming in the abyssal depths of the Atlantic and the other large ocean basins, it was taught but a few years ago that the Chalk itself was deposited in an ocean of similar depth. The *mare clausum* theory, however, is of itself a sufficient obstacle to the acceptance of such a view, since it is impossible to conceive that a sea of such small dimensions could ever have had depths at all approaching those of the Atlantic. The Atlantic theory, if we may so call it, of the Chalk was, however, at once and for ever dissipated by the researches carried on during the voyage of the "Challenger." Those researches showed that the so-called abyssal deposits, instead of being very like the Chalk, were really very different. Even the ooze has not the purity of the Chalk; while the large areas of red clays covering the ocean basins have no analogy in the latter. Moreover, it has been proved that the abyssal deposits are laid down at a rate of almost inconceivable slowness—so slowly indeed that even meteoric dust forms an appreciable portion of the red clays; while the ear bones of whales and teeth of sharks that strew the ocean floor have lain there so long as to have become coated over with a thick layer of manganese precipitated from the water of the ocean. On the other hand, the remains of fishes and other delicate organisms which occur so beautifully preserved in the white Chalk clearly indicate that its deposition must have been comparatively rapid, and must have taken place in a sea where there was abundance of mineral matter either in suspension or solution. Again, the fauna of the Chalk, especially the sponges, is one such as would be found in comparatively shallow seas, and is quite unlike that of the Atlantic depths. Indeed, it is quite probable that the Chalk sea may not have exceeded some one to two thousand feet in depth. The great difficulty in regard to the Chalk is, indeed, to explain its purity, and the very rare occurrence of drifted materials found embedded in it. The *mare clausum*, with no tides and perhaps but few large rivers flowing into it, and its shores largely composed of hard crystalline rocks like those of Scandinavia and the Ardennes, will, however, to a certain extent remove this difficulty. Even then, however, it is doubtful how sufficient material for the formation of the Chalk could have been obtained; and accordingly one of our most eminent living geologists suggests that, in addition to its partially organic origin, Chalk may have been largely formed by a chemical precipitate of carbonate of lime.

Be this as it may, the degradation of Chalk from its former position as a supposed typical abyssal deposit has taught the great lesson that almost all the stratified rocks with which we are acquainted were laid down in comparatively shallow water, and consequently has led to the general acceptance of the grand doctrine of the permanence of continents and ocean basins. By this, of course, it is not meant that the whole areas of several of our continents, such as Europe, have not been (as we know they have), many times over, beneath the sea. Indeed, what we have already said as to the extent of what we may call the cretaceous Mediterranean, shows that at a comparatively late period of geological history a large part of central Europe was sea. Neither does this doctrine forbid such changes in the present configuration of the earth as would be implied by a land connection between Africa and southern India. What, however, it does say, and that in the most emphatic manner, is that where continents now are there deposits have always been going on, and there land, of larger or smaller extent and of ever varying contour, has always been; while the great ocean basins, like those of the Atlantic and Pacific, have existed as such since the globe emerged from its primeval chaos. This, then, is the second great lesson taught by a lump of Chalk!

We have, however, by no means yet exhausted the interest connected with the subject of Chalk. In the first place, the gradually increasing marly character of the lower Chalk points to a condition when the sea was much less deep than at the period of the white Chalk. If, indeed, we go lower down in the rock series, we shall find the white character of the Chalk has completely disappeared when we reach the underlying blue "gault" of Folkestone, which implies the existence of currents or rivers largely charged with mud. Still further back, we have the freshwater clays and sandstones of the Weald of Kent and Sussex; and we thus learn that at that period southern England was in the condition of a large delta, after which there was a gradual subsidence, culminating in the *mare clausum* of the period of the white Chalk. Then, again, we have seen how the "architectural style" of a rock, as exemplified by its fossils, is the one all important point connected with it; and the alteration of the English Chalk into the cretaceous sandstones of Saxony ought to have prepared us for more extensive modifications of these rocks as we proceed to regions still more remote from where they are typically developed. If, then, we turn to a geological map of Europe, we shall find a large area of its southern half coloured in, as being formed of cretaceous rocks—that is, rocks equivalent in point of age to the white Chalk. The description, or still better, an actual examination of these rocks will show, however, that they have but little in common with the white Chalk. They consist, indeed, of hard, compact, and often dark-coloured limestones, containing many fossils identical with those of our own Chalk, together with certain others of different types; thus showing that we have entered an area where the conditions of life were somewhat different from those obtaining in the *mare clausum* of the white Chalk. From the centre and south of France these cretaceous limestones may be traced across the Pyrenees into Spain, and so into North Africa, while eastwards they extend across the Alps into Switzerland, Italy, Bulgaria, Roumania, and thence along the Mediterranean basin into Asia. That these rocks stretch far into the heart of Asia is now well known, and since rocks of somewhat similar type containing well-known European cretaceous fossils are found in the inner Himalayas, it seems highly probable that this southern cretaceous sea connected the Mediterranean with the Bay of Bengal. Whereas similar cretaceous fossils occur on the east coast of India, in the neighbourhood of Madras, and since there are some very remarkable similarities between the freshwater rocks of the peninsula of India and those of South Africa, while many animals are now common to those two countries, there are very strong reasons for considering that peninsular India (which was then cut off from the rest of Asia by the cretaceous sea) had a land connection with the Cape by way of Madagascar. We know indeed that this southern cretaceous sea communicated freely with the Atlantic, by what is now Spain and France, and we are thus led to conclude that there was formerly a direct sea communication between the Atlantic and the Bay of Bengal by way of central Asia. Europe and Asia then formed a northern continent separated by this cretaceous sea (of which the Mediterranean is the shrunken remnant) from a southern continent which included both Africa and India proper.

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Such is the wide interpretation given to the doctrine of the permanence of continents and ocean basins.

The study of the European Chalk, besides the two great lessons to which we have especially directed attention, has, therefore, proved to us the former existence of two great seas, in which the cretaceous rocks were deposited—the northern one being a *mare clausum*, cut off from the Atlantic, in which was deposited the white Chalk; while the southern one, in which the hard, massive limestones of southern Europe were laid down, formed the connecting link between the Atlantic and the Indian Ocean, to which we have already alluded. We might pursue our subject further, and discuss the origin and nature of the flint and pyrites which are of such common occurrence in the Chalk, or we might direct attention to the more valuable and much rarer phosphates which are sometimes contained in it. We might, again, discuss the peculiar characters of the cretaceous fauna, and show how that of the closed northern sea differed from that of the open southern ocean. We might do all this, and more; but what has been written is sufficient to show the amount of interest and the many weighty problems connected even with a "Lump of Chalk."

ANTS' COMPANIONS.—II.

By E. A. BUTLER.

UNQUESTIONABLY the most curious of all the beetles that associate with Ants is the little *Claviger foveolatus* (Fig. 2), which lives specially, though not exclusively, in the nests of the Yellow Ants (*Lasius flavus*). It is a shining, hard-bodied, reddish yellow insect, no more than one-twelfth of an inch long, with a broad abdomen which carries a deep pit in its centre, but a small, narrow, and almost rectangular head. Though belonging to a different family, it in some respects resembles the Brachelytra, of which we spoke last month, inasmuch as it has, like them, short elytra covering only the base of the abdomen; but there are no wings underneath these, the insect being apterous and unable to fly. It is also mutilated in other respects; for instead of the pair of claws with which each foot of an insect usually terminates, only a single one is present on each. The small size of the head, again, is partly due to the absence of eyes, for the beetle is quite blind; but, apparently to compensate for the loss of this one function, the other organs of sense, the antennæ, are exceptionally large, thick and club-shaped, suggestive of a high development of whatever sense, whether of smell, touch, or any other, resides in them. Further, the beetle seems to have lost the power of feeding itself, for its guardians feed it in the same way as their own young, and its mouth organs are quite rudimentary. Here then we have an insect which has lost the powers of flight and sight and of helping itself to food, and which would plainly be doomed to speedy extinction but for the fostering care of the Ants. We have spoken of its having *lost* the above powers, advisedly; for though there is of course no *direct* evidence on the subject, yet when we compare the insect point by point with other members of the same family which do not make it the rule of their life to practise parasitic habits, and are in full possession of all their powers except that of flight, and when we see how exceptionally well developed their eyes and feeding apparatus are, it seems impossible to resist the conclusion that in *Claviger*, which, while unlike them in these respects, closely resembles them in others, we have an instance of the suppression of parts through disuse. The family in question is called *Pselaphidæ*, and is represented by a large number of small species in different parts of the globe; in this country we have a little more than thirty kinds, all minute insects, *Claviger* being one of the largest. Many of them are common, and they may be found in moss, under stones, amongst dead and decaying leaves, in refuse heaps, &c. They have strong, sharply-notched jaws, and are carnivorous in habits, being supposed to feed chiefly on mites. Fig. 3 shows the head of one of the commonest of the *Pselaphidæ*. In it we may specially note the extremely prominent, mulberry-like eyes, and the very long maxillary palpi, which look like a second pair of antennæ, in extraordinary contrast to the mutilated condition of the head of *Claviger*. This is the condition of most of the *Pselaphidæ*, and it shows what might have been expected in *Claviger*, but for its parasitic habits. It will be observed that, though *Claviger* has very stout antennæ, the number of joints is much less than in the rest of the family.

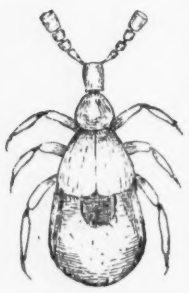

FIG. 2.—*Claviger foveolatus*, a blind beetle found in Ants' nests; magnified fourteen diameters.

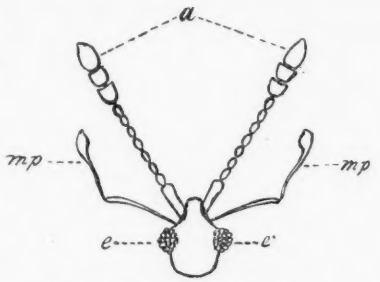

FIG. 3.—Head of *Pselaphus Heisii* for comparison with *Claviger*. *a* antennæ, *mp* maxillary palpi, *e* eyes.

This remarkable little beetle carries at the outer corner of its elytra certain tufts of yellow hairs, which the Ants have been observed to take in their mouths and lick, sometimes continuing the operation for eight or ten minutes at a stretch. The hairs apparently yield some kind of secretion which is agreeable to the Ants' sense of taste, and thus one can easily understand that "cupboard love" will operate strongly in the direction of inducing the Ants to take the greatest care of their interesting charges. The extreme importance of these tufts of hairs and their secretion to the little beetle is evident; its life, as a species, literally hangs on these threads, and this very fact tends in the direction of improving the organs, and thus securing to the species a more certain tenure of life. The beetles are found in those nests of the Yellow Ant which are constructed under stones, especially in the chalky districts of the South of England, but apparently not in those that are under turf. The beetles are attended by the Ants, and carried about from place to place as occasion requires, though of course they can walk themselves if they choose; their pace, however, is but sluggish.

We have already pointed out that *Claviger* is not to be found in all the nests of the Yellow Ant; the same remark holds good of the other species of Ants with which it may be associated. Lespès has made the observation that specimens of the beetle which had been removed from a nest of the common Garden Ant (*L. niger*), on being transferred to another nest belonging to Ants of the same kind, but in which no such pets were kept, were destroyed and eaten, instead of being cherished. He concluded that this was an indication of their failure to comprehend the use of the beetles, and that therefore different communities

amongst the same species of Ant had reached, so to speak, different degrees of intellectual development on the subject of the domestication of alien insects. Sir John Lubbock's experiments in connection with another pet, which we shall consider more in detail presently, seem, however, to throw some doubt on such a conclusion. *Claviger* is not the only member of the *Pselaphidæ* which may be found in Ants' nests; several others may also be met with occasionally, but they have not the degraded habits and structure of *Claviger*, and their occurrence in the nests is not therefore a matter of prime necessity to themselves. One species, called *Batrisus venustus* is a rare insect, and is said only to occur *singly* in the nests.

Another Ants'-nest beetle is figured in the adjoining illustration (Fig. 4). It is one of the Brachelytra and a member of a genus (*Myrmedonia*), all the species of which are associated with Ants. They do not, however, appear to be on such intimate terms with their hosts as the beetles already mentioned, and indeed it is considered by some observers that the Ants, so far from cherishing them, regard them with distrust and suspicion. They are all brownish or blackish insects, larger than those already mentioned, of fragile structure and active habits. Many other of these myrmecophilous (Ant-loving) beetles might be illustrated with advantage; indeed, a complete portrait gallery of the whole company would be an interesting collection, revealing, as it would, the wonderful diversity of form, colour, and size which marks these immigrants into Ant territory. But we must pass on to other branches of our subject.

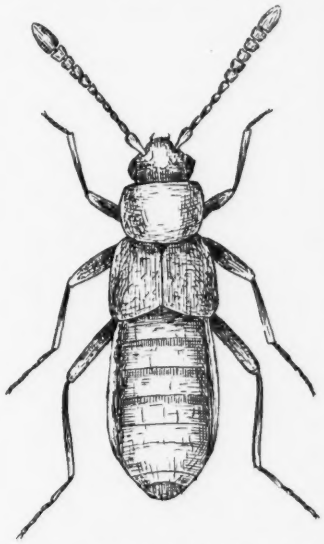

FIG. 4.—*Myrmedonia funesta*, a beetle found in Ants' nests; magnified ten diameters.

The larvæ of beetles are sometimes found in Ants' nests, though the perfect insects live elsewhere. Thus the brilliant rose-beetles or rose-chafers, which, in their perfect condition, may be found in the flowers of roses, proceed from fat whitish grubs, which are to be met with in the heaps of the mound-building Ants. No greater contrast could be imagined than between the soft, ugly, fleshy grub and the hard-skinned handsome beetle, which, as it rests embosomed in rose petals, with the sun shining on its brilliant golden green or coppery back, is a perfect gem of loveliness. In the Ants' mounds the grubs find a comfortable home as well as a means of subsistence, while one species has been accused of making a traitorous return for the shelter it receives by devouring the Ants' "eggs." Similar habits pertain to the larvæ of another beautiful beetle of very different structure and anatomical relations, called *Clythra quadripunctata*; its specific name, signifying the "four-dotted," refers to the four black spots that conspicuously mark its long yellowish red elytra; the rest of its body is black. It is a fine-looking insect, about $\frac{3}{8}$ths of an inch long, and its larva inhabits, not very commonly, the nests of the Wood Ant (*F. rufa*), living in a hairy, leathery case, which it drags about, while its head and legs protrude from one end.

The order Hemiptera, or bugs, furnishes its quota of foreign residents in Ants' nests. Some of these bear a superficial resemblance to the Ants; others are quite unlike them, and their presence is probably sufficiently accounted for by the attractiveness of the shelter which the piles of bits of stick, grass, &c., afford. To the same order belong the aphides, which are among the most remarkable of all the Ants' companions; to these we shall recur presently. Of the order Collembola—the springtails, which are so abundant under stones and decaying logs—Sir John Lubbock mentions one named *Beckia albinos*, which exists in large numbers in some Ants' nests. It is a minute insect of an active temperament, like most of its allies, and its leaping power depends on a kind of forked tail bent under the body; this, on being struck on the ground, projects the insect into the air, repeated blows causing it to skip about in a promiscuous fashion, apparently without any very definite idea of where it is going to be landed. These little white creatures run in and out amongst the Ants, which, however, seem to be totally oblivious of their presence, and hence its association with them is probably accidental, arising merely from similarity of habitat. Like *Claviger* they are blind, and would therefore seem to find their way about by means of their antennæ, which are kept in a state of perpetual vibration. Notwithstanding this defect, they are dainty little creatures, and are very particular about their personal appearance, frequently tidying themselves up, and being especially careful about keeping their feet clean. The feet are furnished with comb-like claws, the action of which would of course be impeded by any accumulation of dirt.

A little white woodlouse (Fig. 5) is another interesting Ants' guest. In the association of this creature with Ants there is something more incongruous than in all the other cases we have mentioned, for all these have been associations of insect with insect, though the guests are not of the same order as their hosts; this is a parallel case to the keeping of dogs and cats by human beings, where we have mammal with mammal, though of different orders, Carnivora with Primates. But woodlice are not insects, as their numerous legs, among other characteristics, attest; they belong to the class Crustacea, which contains also crabs, lobsters, shrimps, barnacles, water fleas, and numberless other creatures, and they are some of the chief terrestrial representatives of the class. In their association with Ants, therefore, we find a parallel, not to the instances of domestication referred to above, but to cases in which human beings keep tortoises, lizards, toads, or newts, as pets, and the zoological interval between the Ant and the woodlouse is a wider one than between the Ant and the beetle, the bug, or the springtail. As a group, woodlice are perhaps best known to the majority of persons by a *slate-coloured* representative called the Armadillo woodlouse, which is excessively common in gardens and elsewhere, under stones or under the bark of dead trees, and which has the habit of rolling up into a ball when disturbed, a habit which is not, however, common

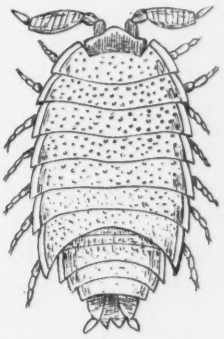

FIG. 5.—*Platyarthrus Hoffmanseggii*, a blind woodlouse found in Ants' nests; magnified ten diameters.

to the group. The Armadillo woodlouse must, by the way, be distinguished from another common creature which superficially resembles it, and which exhibits the same peculiarity of rolling into a pill-like ball; which also is found in similar situations, and especially in the wood of decaying tree-stumps. It is not, however, slate-coloured, but of a deep shiny blackish brown, and the minuteness and disposition of its legs, amongst other less obvious characteristics, pronounce it a member of the class Myriapoda, which contains the centipedes and millipedes, instead of the class Crustacea. It is popularly known as the pill millipede. To the woodlice, then, which are Crustacea, and not to the millipedes, belongs the milk-white Ants' companion above mentioned; but, though we have several species of woodlice in the British Islands, and several of them remarkably common, this is the only one that takes up its quarters in Ants' nests. It is dignified with the extraordinary name *Platyarthrus Hoffmanseggii*. On lifting the stone which covers a nest of the Yellow Ant, we may often see numbers of these little creatures slowly crawling about, like little white scales, very conspicuous by their clean and bright appearance, which contrasts sharply with that of their hosts. What their business in the nests is, remains a mystery, and as the Ants take no more notice of them than they do of the springtails above mentioned, it is evident that they do not, like *Claviger*, form a secretion agreeable to their hosts; but whatever the bond of association may be, it seems to be one of long standing, for while other woodlice have good eyes, *Platyarthrus* has become blind, a very natural result of living long in darkness, in the subterranean galleries of the Ants. In this blind woodlouse we see the same apparent compensation of senses as in *Claviger*, for the antennæ, like those of the blind beetle, are remarkably broad. These white woodlice do not possess the power of rolling into a ball. They have been found living in the nests of at least six different kinds of Ants, and according to Sir John Lubbock's observations, when they were transferred from their native nests to others previously unoccupied by the species, they were received without molestation.

We have now to notice what is perhaps the most remarkable part of our whole subject, the association of Ants with aphides or plant lice. The fondness of Ants for sweets is at the bottom of this association. Aphides secrete the sweet sticky fluid called honey-dew; this, Ants eagerly sip up, and this passion of theirs has led them to the adoption of ingenious devices to ensure a constant supply. This is, however, merely a general statement, and must not be taken as implying either a uniformity of procedure on the part of all Ants, or an identity of treatment of all species of aphides; in the details of their relations, as in other matters, we see well illustrated the variety of Nature. It is an oft-repeated observation that the Garden Ant climbs shrubs and bushes in search of the aphides that frequent twigs; but one would not expect such species as the Yellow Ant, for example, to do this; their time is chiefly spent below ground, and whatever aphides they have to do with will be found either in or near their own nests, and therefore on low plants. The tree-infesting aphides have each a pair of minute tubes projecting from the hinder part of the abdomen, and out of these issues the glutinous secretion, while its flow is accelerated when the Ants tap the body of the aphis with their antennæ. Some Ants get no farther than this; such would live chiefly on what they can get in their foraging expeditions, making no provision in their own nests for a continuous supply of food of any kind, subsisting, as it were, from hand to mouth. Others, however, have reached a more advanced stage; conscious of the value of the aphides as yielding a continuous supply of an agreeable article of diet, they in some cases build earthen sheds over them, as well as protecting them by their own individual exertions from the attacks of enemies. Others, again, have got still farther than this; not satisfied with protecting the mature aphides, they take care of the eggs also, keeping them in their nests through the winter with provident sagacity, securing thus the safety of their next year's supplies. The observations of Sir John Lubbock in this connection are very remarkable. The Yellow Ant was again the species observed. In a nest of these insects he found on one occasion in the month of February some dark eggs, which were those of the aphides; when the nest was disturbed the Ants manifested great anxiety over these eggs, and carried them down into a place of safety. Some of these eggs he took home and offered to some of his own Ants; they were immediately recognised by the Ants and carried into the nest; in about a month's time they were hatched and yielded young aphides. But now came a remarkable result: the young aphides, instead of stopping in the nest, a result that might fairly have been expected to follow, either came out of their own accord or were carried out by the Ants; not finding outside, however, such a food plant as they wanted, they soon died. Some other experiments were equally unsuccessful, but at length the truth of the matter was accidentally discovered. In this last experiment there happened to be near the nest some wild plants, such as usually grow near Ants' nests, and when the aphides were hatched they were taken by the Ants straight to this spot and placed on the leaves. Then, shortly afterwards, others similar to these, and either brought out by the Ants or of independent origin, were found on a daisy plant near; the Ants valued them sufficiently to run up a wall of earth around them, and thus the whole set continued flourishing throughout the summer. In the autumn they laid eggs similar to those that had been found in the Ants' nests. So the secret was out. The Ants took charge of the eggs during the winter, when they were of no use to them, but when, if left outside, they would have been exposed to all the vicissitudes and rigours of our English climate. When spring arrived and the eggs hatched, and the insects were becoming useful to their guardians, they were actually carried out by these and placed on plants near the nest where they could enjoy suitable food, and where also they would be easily accessible to their owners, who to protect their property proceeded to construct works and enclose them in a suitable preserve. This certainly looks like very marvellous intelligence.

But besides these aphides which are supported on the leaves of living plants outside the nests of the Yellow Ant, several species are also habitually found inside the nests. It is not altogether clear, however, what is the relation between these aphides and the Ants. There is a whole section of the tribe of aphides, which, instead of attacking the leaves and young shoots of plants, live upon juices obtained from their roots, and therefore necessarily dwell under ground. They differ a good deal from the rest of the tribe; for example, no winged forms are known in connection with them, and they are destitute of the two tubes above referred to as honey taps, and their bodies are covered with a waxy substance which exudes as a gummy secretion from certain small openings on the back. This substance seems intended to protect the insects from the damp of the soil by which they are surrounded, as well as to cover their eggs. Now, most species of this group are found in Ants' nests, but since the loose sandy soil and the warm situations chosen by the Ants are also just those that suit the aphides, it does not follow that the association is

more than an accidental one caused by similarity of habitat. Mr. Hardy, speaking of one of these root-feeding species, says, "When *Forda formicaria* (the aphis) prevailed in the nests of *Formica fuliginosa*, I noticed that the Ants paid no attention to *them* when the hillocks were disturbed. The aphides slowly re-covered themselves with earth, and those which failed to do so were left quite unnoticed by the numerous Ants running about them." In other cases, however, the aphides were carried off by the Ants, a good deal of persistency being manifested by them in doing so. Mr. Buckton surmises that these wingless subterranean aphides may ultimately turn out to be secondary forms (dimorphs) of species whose winged forms are found above ground.

Aphides are not the only insects whose glutinous secretions are palatable to Ants. M. Nicéville, in the "Journal of the Bombay Natural History Society," describes the caterpillars of certain butterflies belonging to the *Lycænidæ*, found in India, which secrete a sweet liquid from an oval opening on the back of the eleventh segment of their body. The Ants are fond of this liquid and excite its flow by stroking the caterpillars with their antennæ. They are said to arrange a sort of earthen nest, with stalls in it, at the foot of the tree on which the caterpillars are feeding, and when the caterpillars are about to pupate, to lead and drive them into this, so that they may be protected when in their helpless pupahood. When the time comes for the issue of the butterfly, it is helped out of its shell with tender care by its guardians, but if it should prove a cripple, they bite off its wings and carry the body into their nest, possibly to use as food. Other insects, also, especially some belonging to the Homoptera or Frog hoppers, are valued by Ants for secretions which they supply.

To conclude then, it appears from what has been said above, that the relations between Ants and other insects are of the most varied and complex character; the more they are studied, the greater seems to be the variety. Much yet remains to be discovered—in fact, the unknown probably far exceeds the known—so that here is a tempting field of observation for anyone who has the courage and opportunity to enter upon it. M. Carpentier has very well summarized some of the chief facts so far as at present known, and with an extract from his summary we will close this paper: "Some insects live side by side with Ants of all kinds, because they have the same habitat, the bark of fallen trees, old stumps, flat stones, moss, &c. Mutual forbearance is then the order of the day; and the necessary neighbourly feelings are maintained, while at the same time the rights of all are respected. But other insects are attracted by the kitchen stores of the Ants, by their refuse matters, by the different materials that they use in their building operations, or by other unknown causes, whether casual or constant. They may also be born in the Ant-hills, having been brought in unintentionally by the Ants in one of their earlier stages, along with the provisions which they go out to collect from a distance."

PHOSPHORUS MIRABILIS.

By VAUGHAN CORNISH, B.Sc., F.C.S.

ANY substance capable of shining in the dark was originally termed *a phosphorus*. Several substances having the property were known as early as the middle of the seventeenth century, such, for instance as barium sulphide, the "Bonnonian Phosphorus," to which may be added the sulphides of calcium and strontium. The power of barium sulphide and similar bodies to *phosphoresce* depends upon their being previously exposed to light. When a ray of light falls on any substance, part is reflected and part absorbed. As long as the body is exposed to the ray of light it is itself a source of luminous disturbance, and consequently a visible object. The peculiarity of substances such as the sulphides of the alkaline earths is that they continue to be a source of luminous disturbance for a time, when no longer exposed to the ray of light. This power of a body to store up, and slowly dole out the luminous vibrations it receives is called, in physical optics, *phosphorescence*.

Bodies having this property are termed phosphorescent bodies.

Of all substances luminous in the dark, common yellow Phosphorus is the best known, and the example which most people would cite as that of the typical phosphorescent body. Singularly enough, the causes which induce the glow of the chemical element Phosphorus are altogether distinct from those we have mentioned as the cause of phosphorescence in barium sulphide and similar bodies. The terminology of the subject has undergone a peculiar alteration since the seventeenth century. At that time any substance capable of shining in the dark was called "a Phosphorus." Now, the name Phosphorus is restricted by chemists to one chemical element. The element in question exists in more than one allotropic modification, and one of these forms (red, or amorphous, Phosphorus) does not shine in the dark.

While, on the one hand, chemists have made the term Phosphorus special, instead of generic, physicists usually apply the term phosphorescent to a whole class of substances; but "Phosphorus" does not belong to this class.

In the present article we will give a short sketch of the investigations which have been made into the subject of the "Glow of Phosphorus." Ordinary yellow Phosphorus was first prepared by an alchemist of Hamburg named Brandt, and in spite of the care with which the secret of its preparation was guarded a number of persons soon became possessed of the method of manufacture. The early methods, however, gave but a small yield, and were so difficult to carry out that the substance remained for long an extremely expensive chemical curiosity. Its many remarkable properties were a favourite subject for exhibition among the learned and curious, and earned for Brandt's production the name of the *Phosphorus mirabilis*. Robert Boyle observed that the *Phosphorus mirabilis* differed from other shining bodies in that its luminosity did not depend upon its being previously exposed to light. Subsequently it was observed that if Phosphorus were brought into the vacuous space above the mercury in a barometer tube the body no longer shines in the dark. It seemed probable, therefore, that the glow was induced by the presence of air. As in most phenomena in which air takes part oxygen is the active agent, it appeared likely that the glow was due to some action between the Phosphorus and the oxygen of the air. It was found that in pure oxygen Phosphorus at the ordinary temperature and pressure did not glow at all. The glow can, however, be induced either by "partially exhausting" the oxygen in the vessel (*i.e.*, by diminishing the pressure), or by raising the temperature. If after the latter means had been adopted the oxygen were compressed, the glow again disappeared. Now, at the ordinary temperature Phosphorus volatilizes, or evaporates at a very appreciable rate. From these facts, therefore, it seemed probable that the glow was due to an action between the vapour of Phosphorus, and oxygen, the two factors essential for the production of the glow being the presence

of oxygen and conditions favourable to evaporation. The correctness of this conclusion is well shown by the following facts. If Phosphorus be placed in hydrogen, or in carbonic acid, no glow is seen, but traces of Phosphorus vapours can readily be detected in the gas. When one of these gases charged with the vapour of Phosphorus is brought into contact with oxygen gas, a glow is at once observed. This glow is stronger in the case of hydrogen than when carbonic acid is used, which is in accordance with the fact that Phosphorus evaporates more readily in an atmosphere of the lighter gas.

It appears that the glow of Phosphorus in oxygen is in some way connected with the presence of ozone.

It is a well-known fact that when a stick of Phosphorus is placed in moist air, ozone is produced, and it has further been observed that if a drop or two of ether, or oil of turpentine, substances which destroy ozone, be placed in the ozonized air of a vessel containing a piece of the Phosphorus, the glow of the Phosphorus is at once quenched.

It appears probable that the glow is nothing else than a very feeble flame, which may be seen when circumstances are favourable to the oxidation, or burning of the Phosphorus. If the temperature be raised to a moderate degree the combustion takes place with greatly increased energy, and we get the ordinary flame of burning Phosphorus. Recently Professor Thorpe, and other workers at the Royal College of Science, have investigated a similar case of phosphorescent appearance due to oxidation. This occurs with the *trioxide* oxide of Phosphorus.

When Phosphorus is burnt in a rapid current of air, one of the principal products is the trioxide which is capable of combining with a further dose of oxygen, forming the better known and more stable substance, pentoxide of Phosphorus.

The phenomena accompanying this oxidation of the lower oxide (the trioxide) have of late been carefully studied. A phosphorescent appearance is observed when oxidation occurs, and it has been found possible, by varying the conditions of temperature and of pressure, to pass insensibly from the feeblest glow to the most brilliant combustion.

The trioxide is a more volatile body than Phosphorus itself, and better adapted for experiments to show the gradual passage from the "degraded combustion" of the "glow" to the ordinary burning with visible flame.

There are other well-known appearances besides those presented by Phosphorus, which are due to degraded combustion; one example is furnished by the feeble lambent flame seen *inside* the wire gauze of a Davy lamp in "fiery" parts of a coal mine. The conducting power of the wire gauze distributes the heat of the flame over a large area, and prevents the inflammable gas outside the lamp from becoming heated to the point at which explosion occurs.

The *Ignis fatuus* is quoted as a still more striking example of the *degraded* combustion of an inflammable gas. Marsh gases, the slow combustion of which is seen in the feeble flame of the will-o'-the wisp, consist largely of methane, or fire damp, the explosive gas of mines.

Their slow oxidation (or degraded combustion) by the air of the marshes produces at night time a faint glow of uncertain or shifting position, to whose misleading light have been attributed difficulties of the road, as many as have beset the search of scientific men after the true cause of the glow of Phosphorus.

THE NEW STAR IN AURIGA.

By E. W. MAUNDER, F.R.A.S.,

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"NEW" or "temporary" stars as they are sometimes called, offer many perplexing problems for solution, and so far we have certainly not arrived at any satisfactory conclusions respecting them. First of all, we have the paradox that they are evidently very minute bodies, for they cool very quickly, quicker than a body even the size of one of the minor planets could do, whilst they are also equally clearly very large bodies, for in no single case has an appreciable parallax been found for any one of them. They are therefore situated at extremely remote distances from us, and hence must be vast indeed for us to perceive them at all when far off.

Their spectra, too, rather confuse than help us. The bright lines of hydrogen, and many of the chromospheric lines familiar to us in the sun, point to a body similar to our sun and the stars of the same class. But then, again, we have other lines shown, which suggest analogies to the Orion stars, supposed, with so much probability, to be but recently formed from the diffused nebulous matrix of that constellation, and on the other hand we have appearances which suggest kinship with the stars of the third type of spectrum, a type usually supposed to represent a cooler, more condensed stage than that even of the sun.

The first difficulty has been attempted to be surmounted by supposing that we have in a "new" star: (1) A momentary flicker on the part of a nearly extinct sun. It has been suggested that the still glowing nucleus is skinned over by a thin non-luminous or feebly luminous crust, that in some way or other this crust is temporarily broken up, and for a time the hidden light and heat are able to radiate themselves forth. (2) Or it is supposed that the increase of brilliancy relates merely to the very surface of the star, and does not denote any general increase in temperature of the star itself. (3) Or that both statements of the paradox are true, and the star is both very minute and very large; or rather that it is composed of bodies individually very minute, but in the aggregate having an immense extension, and considerable mass; in other words, we have not to do with a star in any true sense of the word, but with a stream or streams of meteorites.

How do the facts which we have learned concerning Dr. Anderson's new star accord with these theories?

The first fact that we have is the increase of brightness of the star, from fainter than the eleventh magnitude on November 2nd to brighter than the fifth magnitude on December 20th. The photographs taken by Prof. Pickering are our warrant for this statement. The star therefore increased in brightness one thousand fold in less than seven weeks, quite possibly in even a few days or hours.

The next fact is that the principal source of this added brightness lay in most intensely heated gases. The evidence for this fact is the extreme brilliancy of the bright lines which glowed in every part of the spectrum, from as far down in the red as the eye could reach to the utmost limit of recordable stellar radiations in the ultra-violet. The existence of a bright line spectrum is in itself sufficient evidence that it proceeds from highly heated gas; the existence of groups of such lines in the ultra-violet, as far as lines have been discovered in the spectrum of the mighty Sirius, is the most emphatic testimony we could

have as to the intensely high temperature to which the star was raised. Dr. Huggins has been able to photograph as bright lines the *entire* series of hydrogen lines which he discovered in the ultra-violet spectra of the Sirian stars, and he has also obtained the clearest tokens of the presence of two groups of bright lines, apparently corresponding to, but more pronounced and developed than, two groups of dark lines which he has but recently discovered in the spectrum of Sirius, and which lie far beyond the last of the hydrogen series.

A third fact is perhaps the most striking of all, the most "sensational," if we may be allowed the term. It is that the lines of hydrogen are present both as bright and as dark lines—and the same is true of the lines of some other elements, such as sodium and calcium for example—but that the body or bodies giving the bright lines are moving in the line of sight as compared with that giving the dark lines at the incredible rate of 600 miles per second, or, in round numbers, fifty millions of miles a day!

Clearly, we have not to do here with the breaking up of a cooling crust and its sinking in a molten sea. Equally clearly, no mere temporary brightening of a photospheric surface is in question; and indeed, that idea is scarcely admissible at all in view of the general opinion of the day that photospheres are condensation surfaces. An increase of temperature might raise the height at which that condensation takes place, and so increase the radiation from the particular star by making the radiating surface greater, but could hardly increase the temperature at which condensation sets in, or augment the brilliancy of the condensed material.

How is it with the meteoric theory? The idea in this case is that two meteor streams, the one dense and giving the dark line spectrum approaching us, and the other rarer and giving the bright line spectrum receding from us, have rushed into each other end on, and their collisions have given rise to the light which appears to us as the star. But, if Prof. Vogel's observations are accepted, the spectrum of the star gives us evidence of not two bodies only but of three, moving in different directions and with different speeds. Two meteor streams might indeed run headlong into each other, and exactly in the line of sight, but three could hardly be expected to do so at the same point. Then, if we accept Prof. Vogel's figures, two of these streams are travelling in opposite directions with velocities the sum of which is sixty millions of miles per day, a speed which would have sufficed to carry a body, during the time that the star has been under examination, right across the solar system, from beyond the orbit of Neptune on the one side, to beyond the same orbit on the other. And during the time the spectroscopic observations have been carried on, this speed of travel has been maintained practically unchanged.

The collision of two meteor streams, therefore, is ruled out of court on two grounds. First, we cannot imagine that the Nova is composed of two streams, each moving with a velocity of some thirty millions of miles a day, and each having a length in a straight line equal to the distance of Neptune from the sun, and encountering each other in direct collision, "end on," and both streams lying in the direction of the line of sight. But the second objection is stronger still. The light and heat come from some source, and arrested or retarded motion, or collision—which need not, however, be held to involve the direct impact of the two bodies upon each other—is the source to which the meteoric theory would ascribe them. But there must be the arrest or retardation of motion; the meteoric stream, or star, cannot spend its energy in light and heat, and have its motion as well. And the development of that light or heat cannot precede the loss of speed. The inconceivable rapidity of motion which the relative displacement of the bright and dark lines indicates must be, on this hypothesis, motion *after* retardation; whilst it does not seem in the least likely that one meteor stream should be purely gaseous, and the other give the continuous spectrum, crossed by absorption lines, typical of the incandescent solid surrounded by absorbing vapours.

A variation of this theory suggests one meteor stream plunging into a nebula. This is distinctly an advance, because we could imagine the meteors consumed as they reach and are arrested by the nebula. The bright lines, then, would express the local heating of the gases of the nebula by the friction of the meteorites as they plough their way into the nebula. But we should recognise the bright lines in this case as partly the lines of the elements characteristic of the meteorites, and partly as the typical nebular lines. This is not the case. The typical nebular lines—other than those of hydrogen, which are common to most stars—are all wanting. There is no evidence of a collision between a meteoric swarm and a nebula. The hydrogen lines, the coronal line, many prominent chromospheric lines are recognised, but though one bright line lies close to the chief nebular line the general verdict of the best observers is against any actual identity, and other lines, only less characteristic, are clearly not present.

Yet another circumstance which tells against the theory is, that though the continuous spectrum is over-borne and disguised by the spectrum of bright lines, yet the former is believed to show traces of that peculiar type of spectrum so beautifully shown by Mira Ceti, α Herculis, and other variables. The same circumstance was reported of the first Nova examined by the spectroscope, and the appearance of the violet and ultra-violet hues of hydrogen as bright lines in the spectra of variables like Mira seems to establish an important link between variables of long period, and "temporary" stars like T Coronæ, and our present Nova. But the shaded bands of the third type spectrum are certainly not what we expect from a nebula.

There can be no reasonable doubt, I think, that the basis of our Nova is a real star or sun, and not a mere gaseous nebula, though in some way or other yet unexplained its luminosity was increased for a few weeks one thousand fold. If we suppose a sun, usually quiet and dull, suddenly bursting out with prominences and metallic eruptions on a scale utterly dwarfing anything ever witnessed upon our own sun, we should have a spectrum very like that shown by the Nova, except in one most important detail. We find, in the solar prominences, evidence that the hurling forth of matter with tremendous velocities so heats the cooler hydrogen atmosphere above the chromosphere as to cause it to glow with those ultra-violet lines which are not, at least normally, found in the general spectrum. A speed of 700 miles per second far exceeds anything recorded of the ejective speed of our solar storms, so that we have to conceive of far more violent convulsions than the sun ever displays. But supposing such convulsions brought about, it is easy to imagine that for the time being a far greater part of the light of the star might proceed from what we might call its chromosphere, prominences and corona, than from its photosphere. In such circumstances the bright line spectrum, which would certainly in its principal lines, and probably in its subordinate ones, closely resemble that of our Nova, would be the most prominent feature.

Unfortunately, in this case, the bright lines would be displaced towards the blue instead of towards the red; the heated gases would be approaching us, not receding from us, as we find to be actually the case.

XUM

This circumstance is one which leads me to make a suggestion, which I put forward with much diffidence and a clear apprehension of many defects in it, for indeed we are yet far from possessing enough material to theorize upon.

We have seen it happen again and again, in our own solar system, that a comet has swept round the sun at so short a perihelion distance that the two bodies must almost have grazed each other. Suppose we put instead of a comet a long and dense stream of meteors; suppose too that the perihelion distance of the meteor stream lies *within* the radius of the star, and that the orbit of the meteors is so presented to us that their motion at perihelion is almost entirely in the direction of our line of sight. The maximum speed in the orbit which such a stream could attain in our system is 380 miles per second. It is readily imaginable that other suns than ours might be able to raise double such a velocity, that depending upon the mass of the star and the radius of its photosphere. It is quite outside the limits of probability to suppose that two meteor streams should both be moving with a speed of some 350 miles to the second and almost precisely in the line of sight. But there is nothing difficult at all in the supposition that there are many stars which are capable of inducing a velocity of 700 miles per second at perihelion. If then we had a long and dense stream of meteors travelling towards a star, and rushing into it, or just grazing it, as they passed periastron we should have the ordinary spectrum of the star, and superposed upon it the spectrum of the glowing meteorites, and of the components of the stellar atmosphere through which they were rushing. The meteorites would therefore give us a spectrum just as their orbital motion was the highest. This suggestion overcomes the difficulty of supposing that the two colliding bodies are moving both before and after collision with the enormous relative speed which the displacement of the bright lines, as referred to their dark companions, would indicate.

There is another point. A large proportion of the meteors would probably escape capture by the star, and would be seen after periastron on the other side of the stellar disc. But they would be now travelling far more slowly in their orbit, and that orbit would be inclined at a very considerable angle of the line of sight, so that their motion from us would then be at a comparatively slow rate. The principal bright lines, the hydrogen lines certainly, but probably not the lines corresponding to the lower strata of the stellar atmosphere, would then be doubled; the line near the red corresponding to the meteors at periastron, and seen on the one side of the star, and the line nearer the blue corresponding to the meteors after periastron, and seen on the other side of the star. And this is the very appearance which Father Sidgreaves, Prof. Vogel, and other observers have actually recorded.

I should not at all wish to press this suggestion, for the matter is not really ripe for solution. But I should like to point out how vastly more powerful our means of stellar spectrum analysis have become. The present Nova only reached the fifth magnitude, and was entirely overlooked for six weeks after it had reached its maximum. Nevertheless we have acquired stores of spectroscopic information with regard to it which will take long to properly discuss. Its history—especially when the mode of its discovery by an amateur astronomer, armed only with a half-guinea spy-glass, is borne in mind—points therefore to the extreme importance of a diligent watch being kept upon the sky, and especially upon the Milky Way and its off-shoots, for who can tell how many Novæ have flashed out during the past few years which, though not bright enough to attract universal attention, like Tycho's Pilgrim Star of 1572, were yet quite bright enough to have lent a rich harvest of information to the prism and the sensitive plate.

TEMPORARY STARS.

By A. C. RANYARD.

WE have to thank Prof. E. C. Pickering for the photographs which illustrate this number of KNOWLEDGE. There have been great difficulties in reproducing them, and I must apologize for the unsatisfactory appearance of many of the plates. It has been found very difficult to show the numerous lines and great variations of brightness in the spectrum of the Nova, and at the same time to keep the background of sky in the star plate black. I have preferred that the printing should be done so as to bring out the best effect in the spectrum of the Nova.

On examining the reproduction of the Nova spectrum given in our plate, it will be noticed that there are at least eight bright lines, bounded in every case by dark lines on their more refrangible sides. This seems to be more than a chance coincidence, and may probably* be taken as indicating that we have before us the superposed spectra of two bodies, one giving bright lines and moving away from us so that all its lines are pushed from their natural places towards the blue end of the spectrum by the apparent shortening of the wave-lengths—very much in the same manner as the note of a steam-whistle is raised as a whistling locomotive approaches us, and depressed as it rushes away from us—and the other body giving dark absorption lines and moving towards us.

The lines F, G, h, H_1, and a are characteristic of the element hydrogen, and, according to Dr. Vogel of Potsdam, who has compared the place of some of these lines with the places of the corresponding lines in the spectrum of stationary hydrogen in a vacuum tube, the hydrogen of the bright-line-giving star is rushing away from us at the extraordinary rate of 230 miles a second, while the hydrogen giving rise to the absorption lines is approaching us with a velocity of 320 miles a second.

The phenomena observed may, it seems to me, be accounted for by the disturbance produced by the motion of a comparatively small star moving away from us through a nebula which was moving towards us. When a large meteor plunges into our atmosphere, the meteor and a considerable mass of gas driven up before it become, for a second or more, intensely luminous. Large meteors frequently leave a trail of luminous gas around their paths, which remains glowing in the cold regions of the upper air for sometimes twenty minutes or half-an-hour. Such trails generally become gradually broader and fainter, and before their final disappearance they not infrequently subtend an angle of half a degree in diameter, as seen from a distance of 70 or 80 miles—that is, they have an actual diameter of about three-quarters of a mile, although the meteoric body whose motion through the air gave rise to the trail may only

* We ought not to speak with certainty until the intervals between the neighbouring bright and dark lines have been more accurately compared. If the interval between the components of different lines is found to be proportional to the wave-lengths of those lines, the phenomenon may be ascribed with much confidence to relative motion; if not, or if the character of the bright and dark lines does not in every case correspond, some other explanation might be preferred. Father Sidgreaves' negatives, which he has kindly lent me for examination, show that there are at least twenty-five pairs of adjacent bright and dark lines, the dark line being uniformly on the more refrangible side; this evidently points to some physical connection.

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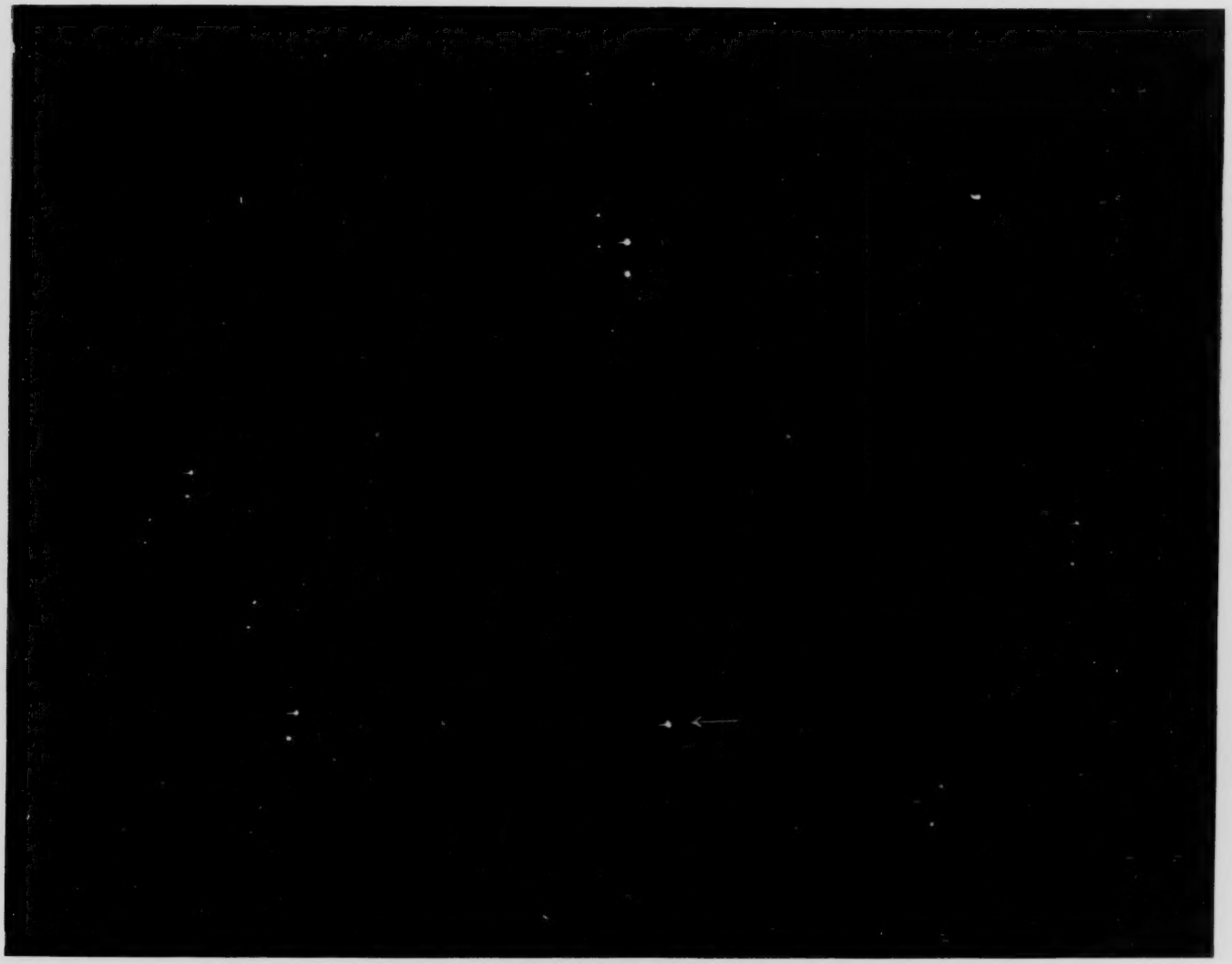
SPECTRUM OF α LYRÆ. From a Photograph by PROF. E. C. PICKERING.

SPECTRUM OF THE NOVA AURIGÆ. From a Photograph by PROF. E. C. PICKERING.



DIRECT PHOTOGRAPH OF THE NOVA AURIGÆ AND SURROUNDING STARS.

Taken by PROF. E. C. PICKERING.

The Automatic Engraving Company, Strode Road, Willesden Green.

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have been a few inches or a foot in diameter. Thus the energy lost by the meteor becomes distributed as heat through a region considerably larger than that originally disturbed by the passage of the body.

If such a disturbance took place on a stellar scale, we should expect to find the matter of the star mixed with nebulous matter driven into a state of intense gaseous incandescence in front of the moving star, and the material left in its wake probably at first in a state of brilliant gaseous incandescence, but soon condensing into incandescent particles, which would give out a continuous spectrum and form a sort of elongated photosphere, the light of which would be channelled by the absorption due to the cool surrounding nebulous matter. We should thus have a bright-line spectrum in which the position of the lines corresponds with the velocity of the moving star, and an absorption spectrum corresponding with the velocity of the absorbing nebulous matter.

The lines which we find as bright in the spectrum of the Nova correspond with lines which are the last to glow in the solar chromosphere, as the matter shot up in the prominences cools.* They, therefore, correspond with the lines which would be the first to glow on being heated.

It is evident that the nebulous matter must be very sparsely distributed, for the velocity of the star does not seem to have appreciably altered in the three weeks, during its passage through the densest part of the nebula. In this period, it must have passed across a region more than equal to the diameter of the orbit of Jupiter. During the whole period in which the star, according to Prof. Pickering's observations, remained above the eleventh magnitude, it must have passed across a nebulous region of greater diameter than the orbit of Uranus. If the matter of the solar system were distributed uniformly through a sphere of the same diameter as the orbit of Uranus, we can calculate the mass of the matter which would be cut through by the passage of a body as large as the earth diametrically across such a nebula; and though no doubt a much larger mass of the nebula would be displaced and heated, it seems probable that a body of the same mass as the earth would not lose an appreciable portion of its velocity in giving an equal velocity to the quantity of matter in the first instance disturbed.

A very significant fact as to the distribution of these temporary stars is that they have all appeared in and about the region of the Milky Way, which is a region of extensive nebulæ. One of the most recently observed of these temporary stars appeared actually near to the centre of the great Andromeda nebula, and its spectrum did not appreciably differ from the spectrum of the nebula. If it exhibited bright lines, they were, like the bright lines of the Andromeda nebula spectrum, exceedingly faint.

THE FLOWER OF MAHOMET.

By the REV. ALEX. S. WILSON, M.A., B.Sc.

THE Prophet-plant (*Arnebia echioides*) is a native of Persia and Arabia, but has been introduced and grows freely in gardens in this country. Its chief interest lies in its variable flowers, which may fairly rank with those of the changeable Hibiscus and other

> "Plants divine and strange
> That every hour their blossoms change."

The plant is about two feet in height, and somewhat resembles a cowslip or an auricula. It belongs to the natural order Boraginaceæ, and is nearly allied to the lungwort, viper's-bugloss, borage and forget-me-not, all of which exhibit colour-changes more or less distinct. The various species of Myosotis or forget-me-not are also called scorpion grasses, from the upper flower-bearing portion of the stem being curled on itself like a watch-spring. The cluster of flowers, forming the inflorescence of Arnebia, develops in the same scorpioid fashion. There is a double row of flower-buds on the curled stalk, and as this gradually unwinds pair after pair of the flowers expand in succession. In shape and colour the individual flowers are not unlike those of the primrose, though rather smaller. When a flower first opens five conspicuous jet black spots are seen upon the yellow rim of the salver-shaped corolla. If the flower be examined the following day, we are surprised to discover that the black spots have vanished as if by magic. The yellow of the corolla is also much paler, and a little later on presents quite a bleached or silvery appearance, the petals becoming almost white. No sooner have the spots disappeared from the first pair of flowers than a second pair expand, and display their sable marks in bold relief upon the yellow enamel of their petals. From this time onwards the inflorescence comprises both kinds of flower, those but newly opened having the five conspicuous spots, and older ones on which no spots are visible. From these dark spots—the so-called finger-marks of Mahomet, Arnebia has received its name—the Prophet-plant. Its flowers seem bewitched, the change is so pronounced and obvious; a day or two after unfolding they differ so much from the newly-opened ones beside them, that were they growing on separate plants, we should at once set them down as belonging to another species.

This change of colour gives rise to another interesting peculiarity. If Arnebia be examined by daylight, and again in the dim twilight, the observer is struck by a remarkable circumstance. In broad daylight, the golden spotted flowers at once arrest the eye, while their paler companions are hardly observed. The inflorescence owes by far the greater part of its display to the younger flowers. In the dusk this is entirely reversed; the conspicuousness of the inflorescence now depends on the paler flowers, and the others are so obscured that a second glance is needed before they can be discerned. The relative brilliancy of the two sets of flowers can also be tested by gradually retiring from the plant, keeping the eyes still fixed on the blossoms. At dusk the young flowers are lost sight of much sooner than the others; by day the older ones first disappear in the distance. This peculiar transformation imparts to the inflorescence of Arnebia a faint similitude of the pillar of cloud by day and of fire by night—that celestial manifestation of sacred story so closely associated with the native region of this desert flower.

Here, then, we have one of those phenomena which, for the naturalist, possess all the fascination of a mystery. What can be the explanation of this remarkable change of colour, and what advantage does the flower derive from the sudden disappearance of its spots and the blanching of its petals?

With the reader's permission, we shall now proceed to show why Nature has bestowed on Arnebia what she has denied to the leopard—the power of changing its spots. Before we can say why any flower should change its colour, we must first know why a flower is coloured at all, and why all flowers are not coloured alike. Almost all the peculiarities of flowers can be explained as having reference to the visits of insects. The honey is secreted

* The vertical storms continually taking place upon the sun preclude the idea that the upper chromosphere is a region only occupied by hydrogen and 1474 stuff. The gaseous matter of the sun must be completely mixed by diffusion as well as churned by solar storms. But in the outer and cooler regions certain elements continue to glow when others have become non-luminous.

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as an inducement, while the scent and brilliant colours serve to attract the attention of the honey-gatherers. The researches of the late Charles Darwin demonstrated the importance of cross-fertilization in the vegetable kingdom. Very many flowers are quite sterile with their own pollen; in other cases, although the flower has the capacity of self-fertilization, the resulting seeds are of very inferior quality compared with those obtained as the result of cross-fertilization. As carriers of pollen, then, insects perform an essential service to plants, and it is in order to secure their services that flowers are brightly coloured.

For the variety of colour observed among flowers there appear to be two principal reasons. A little reflection will show that, since flowers are so dependent on insects for the conveyance of their pollen, it must be to the advantage of each species of plant to possess flowers distinctively coloured and capable of being easily recognised by honey-seeking insects. A bee does not visit all flowers indiscriminately; it would be greatly to the flowers' disadvantage if it did. In the course of a single journey the bee for the most part restricts itself to the flowers of one species, and has been known to visit as many as thirty dead-nettles in succession, passing over all other flowers. Time is saved by this method, for by keeping to one kind of flower at a time the insect becomes familiar with its outs and ins, and the practice thus acquired enables it to overtake a larger number of blossoms than it could if it did not observe this rule. This constancy in visiting the same kind of flower is of great importance to plants, since it insures that the pollen will be conveyed to a flower of the same species as that from which it came. But if all flowers were coloured and perfumed alike, the winged botanist could not identify the species; the pollen would be constantly transferred to the stigmas of the wrong flowers, where it would be useless, and so the work of cross-fertilization would be seriously impeded.

A second cause contributing to the variety observed among flowers is the desirability of attracting special kinds of insects. As we have just seen, an insect does not visit all kinds of flowers indiscriminately; neither, on the other hand, does a flower attract indiscriminately all kinds of insects. Not only are injurious and unprofitable visitors excluded, but the more specialized insects are in greatest demand. Partiality for particular insects is shown both by the shapes and colouring of flowers. Open shallow flowers, with exposed honey accessible to almost all insects, have, as their most frequent visitors, short-lipped flies and beetles. Many blossoms, again, have become specially adapted to bees. Their honey is placed beyond the reach of short-lipped flies, and requires the slender proboscis of a bee or butterfly for its extraction. Honeysuckle, Habenaria, Plumbago, Phlox, and Narcissus illustrate a third type, with flower-tubes so narrow and deep that their nectar is quite inaccessible even to bees, and is reserved entirely for moths and butterflies, which possess an extremely long and thin proboscis. There is a corresponding adaptation in the colours; the gay tints of the buttercup, poppy, and rose appear to have special attractions for beetles; bees show a decided preference for blue, and this colour predominates in flowers whose shapes are adapted to their visits. Deep tubular flowers specialized for Lepidoptera, fall into two divisions, according as they solicit the attentions of diurnal butterflies or nocturnal moths. Red and purple are the favourite colours of the former, while nocturnal moths show a preference for white and pale flowers. Thus, the carnation and campion (*Lychnis diurna*) which open by day, have dark tints in comparison with *Lychnis vespertina*, which unfolds its petals towards evening. Almost scentless by day, this white nocturnal flower diffuses a delicious fragrance in the twilight. The evening primrose (Œnothera), which however, has yellow petals, is another example of this class. But the most remarkable plant of this type is the night-flowering stock (Cereus). Its pale blossoms open about seven in the evening, emit puffs of odour from time to time, and close up again towards midnight; by morning the flowers are withered. It is impossible to doubt that we have in this instance a flower specialized for the visits of nocturnal moths. The reason why nocturnal flowers, like the honeysuckle and evening campion, have pale-coloured petals, is not far to seek. These pale hues can be much more easily distinguished at night than the red and purple of Dianthus or Githago. Among lilies, both diurnal and nocturnal flowers occur, and clearly indicate by their colours to which section of the Lepidoptera they are adapted. The Turk's-cap lily, with its perianth of fiery scarlet, is a characteristic example of a diurnal flower adapted to butterflies which wander abroad in day-time. On the other hand, Lilium Martagon and L. candidum with their white bells are nocturnal lilies fertilized by night-loving moths.

Two flowers, unlike in their colouring, can hardly be equally attractive to the same visitors, even if they grow together on the same plant, as is the case in Arnebia; the presumption, therefore, is that its spotted and pale blossoms are adapted for different insects. Moreover, the stronger colours of the younger flowers correspond with those of the day-blooming class, while the paler tints of those in the second stage will render them more attractive to nocturnal moths; and this view is strongly confirmed by the fact that night-blooming flowers are never variegated, but have their petals uniformly devoid of markings. By night the dark spots tend, in this instance, to conceal the blossoms so much, that, if these are to be converted into nocturnal flowers, the removal of the spots is absolutely necessary. We may therefore conclude with tolerable certainty that the flowers of Arnebia in their first stage are adapted to bees and diurnal Lepidoptera, while in their second condition they array themselves in paler hues to attract nocturnal moths. By the colour-change, in this instance, a diurnal is converted into a nocturnal flower, and one advantage thereby gained is that the blossoms appeal to a larger class of fertilizing agents. The more restricted the circle of visitors on which any plant depends the greater the risk, in the event of insects being scarce, of its flowers remaining unfertilized and perishing. Here it would seem that Nature proceeds on the same principle as a fisherman in changing his bait. Like some other variable blossoms, Arnebia is in the advantageous position of carrying two strings to her bow.

(*To be continued.*)

Letters.

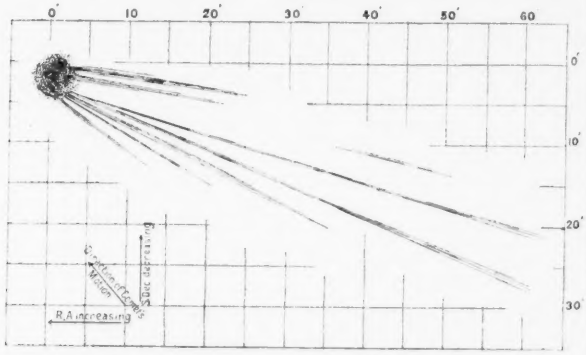
[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

SWIFT'S COMET.

To the Editor of Knowledge.

Dear Sir,—We were unable, owing to cloudy weather, to see Swift's comet until the morning of March 11th; it was then very hazy, and clouds were passing. With the large telescope, only a faint elongation on one side indicated a tail; no sign of rays or other peculiarities could be seen. The star camera was turned to it and a photograph taken with 110 minutes' exposure. When developed, this showed

a tail composed mainly of five ribbon-like rays, the longest of which measured 35′ in length. The rays were equidistant; probably more would have appeared, but the bright moonlight produced a slight general fog on the plate. Cloudy, wet weather followed, and we did not see the comet until the morning of March 22nd. Even then clouds were passing, but the air was clearer. A plate was exposed in the star camera, and out of 2h. 30m. we got 1h. 55m. effective exposure; this photograph shows more of the old rays, one being out to the edge of the plate 70′ long, and three new ones not seen before. One of the first five was visible at a distance from the head, but it could not be seen joining the coma. All these details could be easily seen with a suitable light, but they are too faint to reproduce photographically; and the plate used having on it a grating in squares of 5′, it was decided to make a careful drawing on an enlarged scale, a process rendered very easy



Drawing from negative of Swift's Comet.

by the grating on the negative. It was made by Mr. Sellars, and faith fully represented what could be seen on the negative, excepting only the brilliance of the rays, which it was found necessary to make a little brighter in order to get them to photograph. The negative shows a projection of luminous matter to the sun, and its gradual turning back to form two of these rays. This and other features have been reproduced in the drawing, and the grating on the negative has made it possible to follow these details. Two of the rays could be seen to the margin of the plate, and probably extended beyond it.

Every one is familiar now with the selective action of the sensitive plate in regard to the light of coloured stars, and also in that of nebulous light, for, in photographs of nebulæ, we find details of light and shade, and a structure shown which is wholly invisible through the telescope. In this comet photograph, the same action has evidently brought to light ribbon-like rays which would otherwise have remained unknown; for in the part of the tail visible through the telescope no sign of rays could be detected, even when I knew from the photograph that they were there, and were photographically brighter than the other parts. They are a photographic feature then, and not a visual one in this comet's tail; or, to put it another way, we have a comet with coloured rays in its tail, probably blue or violet rays from the preponderance of blue in cometary spectre. And the sensitive plate, by its *selective powers* as well as by its power of storing up faint light rays, is an aid to vision, and may be used to make a preliminary analysis of cometary or nebulous light, and point the way for more searching analysis by the spectroscope. One morning, through a break in the clouds, we photographed the comet with fifteen minutes' exposure and got rays showing faintly; at the same time, atmospheric conditions were such that we should have photographed an eleventh magnitude star in six minutes. H. C. RUSSELL.

Sydney Observatory, 16th April, 1892.

[The evidence afforded by Dr. Russell's photographs of the bluish tint of certain regions in the tail of this comet is very interesting. It does not necessarily follow that the bluish tint was caused by gaseous incandescence within the streaks, of a different character from that existing in other parts of the comet's tail, or that structures within comets' tails will ever be detected with the spectroscope, for the spectroscope only enables us to detect images due to bright line incandescence and monochromatic light. The bluer character of the light dispersed by these narrow regions may be (and probably is) due to the finer grain of the particles which disperse the sun's light in the regions comprised within the streaks. It has now been known for some years that the light dispersed by the tails of comets is partially polarized in a plane passing through the sun, indicating that the greater part of the light is dispersed by particles which are small in diameter compared with the wave-length of light. Some twenty years ago Lord Rayleigh showed that the colour of the light dispersed by fine particles depends on the fineness of the particles,* and that the finer the dispersing dust the richer is the scattered light in short wave-lengths or blue rays. Thus the dust from Krakatoa at first caused the sun to appear red. As the larger particles floating in the air fell to the ground the sun became green, and ultimately it became blue.—A. C. RANYARD.]

THE GLACIAL PERIOD AND THE PLANET MARS.

To the Editor of KNOWLEDGE.

DEAR SIR,—It seems to me that one of the chief secondary causes of the Glacial Period has not heretofore been sufficiently enforced. During the short winters and long summers, whatever precipitation occurs will be largely in the form of rain. On the other hand, during the long winters and short summers it will be, on the whole, chiefly in the form of snow. Now the snow, by its great reflective power, will cause the earth to lose a very large proportion, perhaps nearly three-quarters, of whatever radiant energy does fall upon it. Moreover, during the short summer, when the sun is able to melt the snow, there will be an extensive evaporation from its whole surface, forming clouds. These will in their turn reflect away the sun's rays, and at the same time by their shade protect the snow beneath them from melting.

This cause requires for its action the presence of considerable moisture upon the surface of the planet. It has been stated that the glacial theory does not appear to apply to Mars. In the case of this planet, however, we have good reason for thinking that it formerly had extensive oceans upon its surface, and the gradual cooling to which it has been subjected has enabled room to be formed for them in its interior; that is to say, there are probably extensive regions in its interior which are not sufficiently hot to convert water into steam. The water would therefore, naturally, as is the case with the earth, go underground, filling all the microscopic cavities between the rocks. Be that as it may, the appearance of the surface of this planet leads us to think that it possesses at present very much less water in proportion than does our earth. That being the case, there could not be sufficient evaporation to form the extensive snow-caps required by the glacial theory. As an illustration of this point, we should

* See a paper "On the Light of the Sky, its Polarization and its Colour," by the Hon. J. W. Strutt (now Lord Rayleigh), in the *Phil. Mag.* for February, 1871, pp. 107-120, and March, 1871, pp. 274-279.

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expect that the northern or continental slopes of the Himalaya Mountains would be colder but also drier than the southern ones, which are exposed to the ocean. Yet upon the warm southern slopes we find the line of perpetual snow considerably lower than upon the colder northern ones. Thus, because the supposed snow-caps upon Mars are small, it does not necessarily indicate that the temperature of the planet is higher than that of the earth.

WILLIAM H. PICKERING.

Arequipa, Peru, April 14th, 1892.

[Prof. W. H. Pickering's interesting suggestion, that as a planet cools its oceans will be absorbed and go to augment the volume of its underground waters, does not commend itself to my mind as explaining the phenomena we observe on Mars. For, in order that the earth should absorb say a mile in depth of its ocean covering, the isothermal surface within the earth, at which water is converted into steam, would need to fall at least three or four miles, and all other isothermal surfaces would fall with it; that is, the mean temperature of the surface, even in the equatorial regions, would certainly fall far below the freezing point. But this does not seem to be the case on Mars.

If we assume, as most speculative astronomers have hitherto assumed, that the white polar caps of Mars are due to snow, it follows that the mean temperature of the Martian surface in the equatorial and temperate regions of the planet must be above 32° Fahr., a fact which is not consistent with the assumption so frequently made, that the mean temperature of a planetary surface must vary inversely as the square of the distance of the planet from the sun. We are, it seems to me, forced to assume either that the polar caps of Mars are not due to snow, or that the mean temperature of the equatorial and temperate regions of Mars is above 32° Fahr.; that is, that they are much warmer than they should be on the assumption that the mean temperature will vary inversely as the square of the distance from the sun. To my mind, the discrepancy is most easily accounted for by supposing that the atmosphere of Mars is more dense than the atmosphere of the earth. I do not see any necessity for the assumption that the amount of the atmosphere and the amount of the ocean on Mars must bear the same proportion to the amount of solid material as on the earth, or even that they must have originally borne the same proportion. It is, of course, possible that we may be observing phenomena on Mars quite dissimilar to those going on here. The white polar caps may be due to the deposition of the snow-like crystals of carbonic acid, which evaporates again at a temperature far below the greatest cold which we experience on the earth's surface.—A. C. RANYARD.]

A CORRECTION.

To the Editor of KNOWLEDGE.

DEAR SIR,—My attention has been called to an error in the *derivation* of the expression for the tangential force in the article on the "Origin of Binary Stars," and I gladly seize the earliest opportunity for correcting the mistake. The height of the tide obviously varies as the *first power* of the tide-generating force, *not as the square*, as asserted near the bottom of the first column on page 82. The couple acting against the rotation of Helios arises from the excess of the attraction of Sol on the nearer tidal protuberance above that on the further. Now this excess is found to vary inversely as the third power of the distance between the two bodies. But the couple also varies directly as the height of the protuberance (*i.e.*, as the height of the tide), and this height varies inversely as the third power of the distance. Hence the tidal frictional couple varies as the inverse sixth power of the distance; or it may be described as varying inversely as the square of the tide-generating force, since the tide-generating force varies as the inverse cube of the distance. If we denote the tidal frictional couple by T, the radius vector by ρ, and the tangential force by t, the principle of action and reaction gives for the equilibrium of the forces $t\rho = T$, or $t = \frac{T}{\rho} = \frac{\kappa}{\rho^2}$. In the fifth line from the top of page 82 (second column), the reading should be "cube" instead of "sixth power." Since the result reached in the article was correct, the error in the *derivation* of the expression for the tangential force does not vitiate my argument, and the conclusions are therefore sound. But as a friend had kindly called my attention to the slip, I thought it ought to be corrected. Very faithfully yours,

Berlin, May 20th, 1892. T. J. J. SEE.

CAN A PLANET BE FINALLY SURFACED WITHOUT A SEDIMENTARY ROCK SERIES?

To the Editor of KNOWLEDGE.

DEAR SIR,—Professor Judd, in his instructive work on Volcanoes, at page 305, tells us that "the Moon appears to be destitute of atmosphere and water . . . under the circumstances we find its surface, as we might expect, to be composed of rocks which appear to be entirely of igneous origin"; and at page 367 he refers to the striking evidence, on the Moon, of the action of volcanic forces, in the vast size of the so-called "craters" (up to 50 and 60 miles diameter).

But inasmuch as Professor Judd's entire work is a peculiarly good demonstration that "without water, there can be no volcano," I should esteem it a great favour if any of your scientific readers can explain the obvious contradiction in the above.

For over ten years I have carefully studied the lunar surface, in the hope of eventually solving this well-known astronomical riddle, and have come to the conclusion that such a globe cannot have been finally surfaced (solely) by igneous and volcanic agency.

The convection and radiation of heat from rock surfaces, as the initial temperature declined, must have been such an exceedingly slow process that it is inconceivable how a globe of that size can have passed from a semi-molten to the airless and waterless stage of development, without the intervention of a very prolonged era of erosive denudation.

Selenographers are agreed that on our moon there is practically an absence of river valleys, and the fluviatile sculpturing so characteristic of our earth's surface; in fact, that the lunar surfacing seems to be due entirely to a deposition of solid dry material, showing a singular and marked absence of all drainage phenomena.

Hence it is urged that there is an absence of sedimentary stratified rocks, what we see being the unchanged results of primeval lava lakes, volcanic outbursts, and "cinder rings," laid during an era of such high initial temperature that water, near the surface, would have been a physical impossibility.

The subsequent decline in temperature, again, is assumed to have been so exceedingly rapid as to preclude the possibility of any erosion of river valleys, and the formation of sedimentary rocks.

An idea prevails that the enormous craters and volcanoes (seen even all over the poles) originated during the period of high initial temperature, and that the cavities, 20 and

50 miles in diameter, were in some way blown out explosively.

What I desire to point out is the improbability—not to say the impossibility—of this being done by volcanic action, as we understand it nowadays, and at a time when the lunar crust, to the very surface, must have been far above the boiling point of water. "Without water there can be no volcano," and hence, with such a high temperature, there being no *water*, there could have been no volcano. There is no escape from this syllogism.

But another weighty argument against the lunar craters being due to volcanic action is their vast size. This is usually accounted for by the fact that lunar gravitation is but one-sixth of ours, thereby enabling an "explosion" to eject matter to six times the distance. When we look into the case, however, we notice that these lunar "safety valves" are only loaded with one-sixth the terrestrial weights. The explosive force, or accumulated ejecting power (due to steam held under superincumbent pressure), is thus reduced in the same ratio, and the power of ejecting matter on the earth and moon is the *same*. The power not being derived from any explosive material, such as dynamite, but being controlled by gravitation, the fallacy of the old reasoning is obvious.

Again, by all accounts our moon at one time rotated on its axis more rapidly, and has been slowed down by vast tides.

If these were of *water*, it is clear that the globe had (then) cooled down so far as to be practically rigid, and the tidal deformation (as in our case) was confined to the fluid envelope, which thus needs must have scoured off all the "cinder rings," and completely filled in the craters and sunk plains, large and small, the ellipsoidal figure of the globe, so strongly insisted on by Proctor (as a true cause for libration), arising subsequently.

If, however, the era of tidal retardation occurred while the globe was in the semi-molten and plastic condition, as Sir R. S. Ball suggests, then the formation of the walled plains (lava lakes) and volcanic craters must have taken place later on, yet still in the absence of water, inasmuch as there is no evidence of its presence then nor yet afterwards, when, if anything, it should have been still more obvious; when one would very naturally expect the enormous atmosphere of vapours to fall by condensation and scour the surface persistently for long ages *during the slow decline in temperature*, at last, perhaps, leading to a development of polar caps and general glaciation.

There is abundant and beautiful evidence in the surfacing of the absence of water, during its formation, and this very evidence, I hold, is fatal to any theory of volcanic surfacing, for which water is an essential element. Even the poles are covered by vast lava lakes, "cinder rings," and so-called volcanoes.

This singular absence of all traces of water, all sculpturing by rivers, and of drainage phenomena in the lunar surfacing, is the great problem which needs solution: whether an era of erosion with deposition of stratified rocks and formation of river valleys is, or is not, logically a *necessary sequel* to a semi-molten stage in planetary evolution; whether a planet could pass from the molten to the airless and waterless stage, and yet retain all through the later stages the surfacing due to a primeval igneous era.

To me it seems easiest to assume that the moon has long ago passed through our terrestrial erosive stage, and now, in its airless and waterless condition, is swathed from pole to pole in snow and ice formations.

Sibsagar, Assam, 15th March, 1892. S. E. PEAL.

[While agreeing with Mr. Peal that the traces of water action upon the moon are not conspicuous, I do not feel sure that there is no evidence of sculpturing by rivers or drainage phenomena. Mr. Neison, in his book on "The Moon," p. 73, is inclined to think that in many points the rills or clefts "bear some resemblance to the dried beds of lunar watercourses or rivers. Thus many of these rills commence at the end of a system of branched valleys leading from a highland, whilst others can be detected winding along the bottom of extensive valley regions." It seems to me also that many of the dark delta-shaped patches, which are frequently found in the planes round lunar mountains, afford evidence of drainage phenomena. There are two such patches on either side of the lunar Appennines, which are well shown on photograph No. 1, published with the number of KNOWLEDGE for December, 1890, and three such dark patches to the west of Copernicus in photograph No. 2 in the same number. These dark regions are also well shown in the photograph published in the May number for 1890.

Though no doubt the greater number of terrestrial volcanoes are adjacent to the sea, some, as those between Siberia and Thibet, and in the Chinese province of Manchouria, as well as the extinct volcanoes of central France, are at a considerable distance from the sea or lakes. Mr. Scrope long ago pointed out that though a considerable amount of steam escapes from active volcanoes, it does not follow that the water producing it was originally derived from the sea. All rocks contain a considerable amount of water of crystallization, and we are probably not warranted in saying that a volcanic irruption could not take place without the presence of an adjacent sea, lake, or river.

Though I do not think that the albedo of the lunar surface has been determined with the accuracy which Zöllner supposed, it seems to me that we have evidence that the whiter portions of the lunar surface are very white compared with any terrestrial rocks, and that it is more probable that the lunar mountains are capped with snow than that the higher regions are formed of very white rocks, while the valleys and low-lying regions are always formed of much darker material. I therefore agree with Mr. Peal as to a large portion of the lunar surface being covered with ice or snow, but it is easier to me to account for the great ring formations, as being analogues to terrestrial volcanoes, than to suppose that they are rings of ice and glacial phenomena of which we have no terrestrial analogues.—A. C. RANYARD.]

THE CORONA OF THE SUN AND STARS.

To the Editor of KNOWLEDGE.

DEAR SIR,—Although the teachings of modern astronomy have led us to look upon many of the fixed stars as veritable suns, merely reduced by their vast distance to a subordinate lustre, the possibility of being able to observe the corona about stars seems to have escaped notice.

During the last seven years, the principal work of this observatory has been the observation of a number of long period variable stars, which decrease in lustre from about the 5th to below the 13th magnitude, in periods ranging from 200 to 600 days. They differ in a remarkable manner from the ordinary fixed stars. Most of them are of a deep red or ruddy colour, and many are more or less nebulous; they may be divided into four classes, viz., stars having

(*a*) A remarkably well-defined, almost planetary, disc;

(*b*) Well-defined stars surrounded by a more or less dense, ruddy atmosphere;

(*c*) Large, woolly stars, with ill-defined image, resembling a small but bright planetary nebula.

(*d*) Stars which at minimum show, in place of the variable, a slight bluish nebulosity.

In the case of a star surrounded by a very faint nebulosity or coronal appendage, we should not expect to see any trace of the corona till the star was nearly or totally obscured, and recent observations show that in several instances, when the star has gradually become so faint as to be invisible with our $6\frac{4}{10}$ inch refractor, its place has been occupied by a pale bluish nebulosity, which has again vanished as soon as the star reappeared, being evidently so faint as to be readily overpowered by a small amount of stellar light.

It may be that all variables are nebulous, or have extensive and bright coronas, but that when the nebulosity is faint, we only become aware of its existence when the light of the variable is reduced to a minimum.

Yours faithfully,

Rousdon Observatory, Lyme. C. Grover.

THE DEPTHS OF THE MEDITERRANEAN AND BLACK SEAS.

By Richard Beynon, F.R.G.S.

ISOLATED as it is from the great water masses of the globe, the Mediterranean—with its off-set, the Black Sea—may be regarded as a provincial sea. The oceanic circulation of the North Atlantic sweeps past its narrow entrance unheeded. The great tidal wave is effectually debarred by the convergence of the African and European coasts from influencing the tidal phenomena of the Mediterranean, and the same cause, aided by the near approach of the strata underlying the Straits of Gibraltar to the surface, precludes the possibility of the chill waters that ever roll equatorwards along the sea floor finding their way into the vast inland sea under discussion. The geographical limits of the Mediterranean are well known, but its true geological boundaries by no means coincide with these. Instead of terminating to the westward at the Straits of Gibraltar, the sea is really continued some 50 miles into the Atlantic, for the shoal water which separates the line of coast between Tangier and Ceuta from the opposite shores of Spain extends westwards to that distance. Here the shallow ridge terminates, and the sea bed rapidly falls into the depths of the Atlantic.

The proximity of the island of Sicily to Cape Bon suggests the very natural division of the Mediterranean into an eastern and western section. Taking the western portion, we find that at its two lateral extremities it is separated by a shallow ridge from the Atlantic on the one side, and the deep waters of the Eastern Mediterranean on the other. The depths of water obtaining on these shallows approximately coincide. The deepest sounding obtainable on the ridge between Cape Bon and Sicily is under 200 fathoms, while the maximum depth in the vicinity of Gibraltar is 180 fathoms.

The shoal water which commences some 50 miles to the westward of Gibraltar is really continued 120 miles to the eastward of Point Europa, almost to the shores of Alboran Island.

If we regard as continental, islands that are separated from the mainland by depths not exceeding 100 fathoms, then Alboran must be classed as an oceanic island, for on all sides it is surrounded with water of 400 fathoms and upwards in depth. The Balearic group present most peculiar features. Instead of forming one group, as their juxtaposition would seem to imply, they make two. Iviza and Formentara are separated from Majorca, Minorca, and the Spanish coast by soundings of 300 fathoms. The two last named islands have a channel of 50 fathoms between them, and to the eastward of Minorca the sea bed has a steep gradient until, 30 miles from the Balearic group, a depth of 1400 fathoms is encountered. A comparatively slight upheaval of the Mediterranean bed would suffice to connect Corsica and Sardinia, for the Straits of Bonifacio are of little depth. Shoal water, too, connects this group with Elba and the mainland of Italy. The shallow channel which extends from Cape Corso, *viâ* Elba, to the coast of Tuscany has an average width of from 15 to 20 miles, and nowhere along it can soundings of a greater depth than 50 fathoms be obtained.

We now come to the easterly boundary of the western portion of the Mediterranean Sea.

From Cape Passaro, at the south-easterly corner of Sicily, a bank with 300 fathoms of water over it extends to the opposite shores of Tripoli, while a somewhat similar ridge, with a lesser depth of 200 fathoms, connects the other extremity of the island with Cape Bon. Between these two banks a deep water gully runs, with an average depth of 600 to 700 fathoms.

With regard to the deep water areas of the western section of the Mediterranean, a fairly uniform depth, ranging between 1200 and 1600 fathoms, is maintained between Marseilles and Algiers, while the deep water lane extending from Naples to Sardinia admits of soundings of 1500 to 2000 fathoms.

These are the more salient features revealed by soundings taken in the western portion of the Mediterranean. Scientific research, however, has added much to our knowledge of the eastern section during the past few years, and it is chiefly to Austria that progress in the study of the oceanography of this part of the Mediterranean is due.

Before the *Pola* expedition the generally received greatest depths obtained in the Mediterranean were 2040 fathoms in the western section and 2150 in the eastern. The latest results, however, show that deeper soundings are obtainable. On the 28th July, 1891, the *Pola* found the depth of 2406 fathoms, and a few miles further to the eastward 2236 fathoms, both of which depths exceed those mentioned above. The exact position of this, the deepest spot yet discovered, is 35° 44′ 20″ north lat., and 21° 44′ 50″ east long., or, roughly speaking, about 50 nautical miles south-west of Matapan. Very properly the Austrian Hydrographical Board have determined to perpetuate the record of their nautical find by assigning to this deep-water spot the name of Pola Deep. This discovery will necessitate the removal of the deepest part of the Mediterranean considerably eastwards from its present position on our maps. Another deep-water area explored by the *Pola* was that lying between Candia and Alexandria, the depths ranging from 1810 fathoms, some 20 miles south-east of Grandes Bay, to 1322 fathoms within a short distance of Alexandria. The serial temperatures taken by this expedition coincide in the main with those obtained during previous researches.

From 80·8° F. to 69° F. was the thermometric range in the first 27 fathoms. In the next 27 fathoms the temperature fell to 62·5° F. The range for depths between 110 and 547 fathoms was 59° F. to 57° F. At the lowest depth found (2406 fathoms), the temperature was 56° F., which, as previous investigators have established, is the approximate uniform temperature of the bed of the Mediterranean. One very curious result of the temperature experiments was the finding of water whose temperature was $52\frac{1}{2}$° F., at a depth of 415 fathoms, at the junction of

the Adriatic with the main waters of the Mediterranean Sea.

It has been found that the temperature of the Mediterranean Sea bed is by no means constant, and, according to some authorities, varies slightly in accordance with the mean temperature of the winter preceding the season in which the temperatures of the sea bottom are taken. Thus in 1871 the *Shearwater* expedition, under Captain Nares and Dr. Carpenter, found a bottom temperature at 1650 fathoms of 56°, and the year previous the same temperature had been met with at a spot where the sea bed was 1743 fathoms from the surface. In 1881, however, Captain Magnaghi, Hydrographer to the Italian Navy, along with Professor Giglioli, in the surveying vessel *Washington*, found the bottom temperature to be 1° higher than that recorded as the mean of those obtained in 1871. The mean temperature of the months of December, January, February, March, and April is 53·6° F. at Toulon and 56·84° F. at Algiers, and the average of these two temperatures gives approximately the degree of heat contained in the Mediterranean Sea bed between those two places.

With regard to the Adriatic Sea, soundings show that only one-third of its area can be regarded as forming a part of the Mediterranean basin proper, the remaining portion not averaging more than 50 fathoms in depth. A channel of 400 fathoms stretches across the entrance to the sea, from Otranto to Albania. Within the sea the depth increases until a maximum of 765 fathoms is attained, and this rapidly shoals until the comparatively shallow waters of the northern portion of the sea are encountered. The *Pola* made some interesting experiments relative to the transparency of the Mediterranean waters, In three cases a white disc was seen down to a depth of 177 feet. Where the water was deepest, however, invisibility was reached at 105 feet.

The paucity of animal life in the great depths of the Mediterranean is well known. Its depths are to a certain extent stagnant. There is an utter absence of that vertical circulation so thoroughly developed in the Atlantic, and which results in process of time in every particle of water being alternately transposed from sea bed to surface, and surface to sea floor. The only semblance of such a circulation that exists in the Mediterranean is caused by the descent of water that has been concentrated by evaporation on the surface, and has thus had its specific gravity raised above that of the underlying strata. But the descent of this water will be seriously interfered with at a depth of 200 or 300 fathoms, where the temperature is such that it will encounter an aqueous layer whose specific gravity is much akin to its own.

It will be remembered that it was owing to the absence of life met with during the researches of Professor E. Forbes, in the Ægean Sea, that the erroneous doctrine was formulated that marine oceanic life ceased at a depth of about 300 fathoms.

Subsequent explorations in the deep sea speedily showed the fallacious character of such a conclusion, except in enclosed seas of the Mediterranean type.

In the western basin of the Mediterranean, the bottom consists chiefly of clay, of a grey or brownish colour. It always contains some carbonate of lime, the remains of foraminifera. Both in appearance and chemical constitution the mud resembles that dredged up in the open ocean from areas which are shut off by submarine ridges from free participation in the vertical oceanic circulation.

In the eastern section of the Mediterranean the sea bed deposits contain a considerable proportion of volcanic ash and other constituents of igneous origin.

Before proceeding to discuss the character of the connecting channels and currents that unite the Mediterranean Sea with the Atlantic Ocean and the Black Sea, we will briefly allude to the findings of the latest researches conducted in the waters of the last named sea.

The Russian gun-boat the *Tchernomoretz* was engaged in June and July, 1890, in the work of surveying. The maximum depth, 7365 feet, was found in the central portion of the sea, between the Crimea and Anatolia. The explorations were continued last year, and the results of the previous year's work were confirmed. The 100 fathoms line was found to lie close to the shores of the Crimea and Anatolia, and the axis of greatest depression has a direction from south-west to north-east. The steepest coast was found at Rizo, where the angle of inclination attains 10°. The most interesting of the recorded observations are those relating to the temperature of the Black Sea waters. The variations of temperature at the surface range from 77° F. to 41° F., while on the northern shores the thermometer sometimes falls below the freezing point. The annual variations of temperature, due to the seasons, do not penetrate deeper than 100 fathoms. At a depth of from 30 to 175 feet the temperature was 57° towards the south coast, 54° in the centre, and 52° near the east, west, and north shores.

The water begins to be warmed by the air in the month of May, and during August the mean temperature of the surface water is higher than that of the superincumbent air. The variation of temperature for depths below 180 feet is very peculiar. At this point the thermometer registers 45° F. Then the thermometer begins to rise, and at a depth of 6000 feet it shows 49° F. For all depths below 200 fathoms the temperature may be described as constant, and lying between 49° F. and 48° F. The most distinctive feature of the Black Sea, however, is that at the depth of 450 feet distinct traces of sulphuretted hydrogen occur. The quantity increases with the depth, until at 600 feet it is quite sensible, and at the mean depth of 940 feet it renders animal life quite impossible. Some even place the inferior limit of organic life at so high a level as 100 fathoms. Dredgings show that at one period of geological history the Black Sea contained an abundance of low organisms, and the semi-fossil shells of certain molluscs characteristic of the brackish water of the lagoons of the Caspian and Black Seas are much *en évidence*. These fossils are doubtless the remains of the Pontic fauna of the Pliocene period, when the Black Sea basin was not connected with the Mediterranean. The salinity of the Black Sea was then by no means so great as it is now. When the connection between the two seas was made, the water from the Mediterranean would make its way as it does at present into the Black Sea area, and speedily lead to the disappearance of the ancient fauna. Thus the sulphuretted hydrogen is one of the products formed by the decomposition of the older life, and as the water in the great depths is practically stagnant, *i.e.*, quite motionless, it follows that the decay is an exceedingly slow process.

Assuming that the water which annually flows through the Bosphorus into the Black Sea forms a one-thousandth part of the total contents of the sea, it will take 1000 years to completely renew the whole contents of the basin. It will be thus easily seen to what small extent the deep waters participate in the scheme of circulation. The Sea of Azov is merely the expanded mouth of the River Don, its waters being shallow, having no greater depth than 7½ fathoms, and being thoroughly mixed by each storm that visits it.

The Sea of Azov, too, shares in the disturbing influences of the surface current which sweeps round the shores of

the Crimea to the north-west, and then follows the trend of western shores past the mouths of the Danube towards the Bosphorus. The dimensions and velocity of this current are augmented when the melting of the snow in the Black Sea basin is more rapid than usual.

We have mentioned above that a decided influx of Mediterranean water takes place into the Black Sea. Were it not for this saline water the Black Sea would be much fresher than it is, and were the connection between it and the Mediterranean destroyed then the sea would become fresher, as there is a surplus of river and rain supply over evaporation. Throughout the whole length of the Bosphorus, the Sea of Marmora, and the Hellespont, two distinct currents can be traced, the heavier Mediterranean water forming the underlying stratum, moving slowly *into* the Black Sea, the lighter water from the latter sea being superincumbent and moving in the opposite direction. There appears to be very little mixing of the two currents, the layer of demarcation between the two being easily detected by the difference in the specific gravities of the two aqueous masses.

The comparatively fresh water that the Black Sea contributes to the waters of the Mediterranean produces but little effect, so large is the area of the basin into which it pours itself and so small relatively is the volume of water so contributed.

The greatest depth of the Sea of Marmora is found along the line connecting the Hellespont with the Bosphorus, and ranges between 266 and 355 fathoms.

The Hellespont itself has a depth of 50 fathoms, while the mean depth of the Bosphorus varies from 30 to 40 fathoms.

The Ægean Sea has not its specific gravity reduced as might be expected below that of the whole Mediterranean by the influx of the Black Sea water. In fact its specific gravity is greater than that of any other section of the Mediterranean basin.

The accompanying table bears out the truth of this. The figures quoted are the result of many observations, and are derived from samples of water taken from 50 miles to the westward of Gibraltar to the easternmost section of the Black Sea.

Mediterranean Water outside Gibraltar	1·0260 — 1·0270
Mean specific gravity for Western Section	1·0280 — 1·0290
Mean specific gravity for Eastern Section	1·0290 — 1·0300
Mean specific gravity for Black Sea	1·0120 — 1·0140

In each case the results are derived from analyses of surface water.

In round numbers the area of the Mediterranean basin is one million square miles, and the average rain-fall over the whole area that drains into it has been assessed as being equivalent to an annual rain-fall of 30 inches upon the sea itself. The amount of water removed by evaporation is greatly in excess of this, probably $2\frac{1}{2}$ times as great. At Rome the evaporation is represented at some 105 inches per annum, at Madrid it is 65 inches, and at Cairo 92 inches. It does not require much speculation to determine what would happen if the waters of the Mediterranean were not replenished from some external source. A shrinkage of the basin by a diminution of the water area would continue until the evaporation from the reduced surface would equal the amount of aqueous precipitation. But before that condition would be reached, the shrinkage would have resulted in the drying of the bank between Sicily and Africa, and between Africa and Gibraltar, with the result that two "dead" seas would be formed.

Happily, there is not much probability of such a change taking place, for the Mediterranean is supplied with water from the Atlantic as well as the Black Sea. Through the Straits of Gibraltar there flow two currents, as there do through the Sea of Marmora. The existence of an outward current has been long known. It is accountable for the higher temperature found in the deep waters of the Eastern Atlantic. Water, unmistakably of Mediterranean origin, has been found some 200 miles north-west of the Straits at a depth of 1560 fathoms. Its presence at such a depth is readily understood when it is remembered that the water of the Mediterranean contains an average of 3·9 to 4 per cent. of solid matter in a state of solution, while the percentage in Atlantic water in the vicinity of the Mediterranean entrance is 3·4 to 3·5.

It has been calculated that the *inflow* through the Straits is equivalent to a river eight miles wide, 100 fathoms deep, running with an uniform velocity of $18\frac{1}{2}$ miles in the twenty-four hours. Such are the dimensions of a current requisite to maintain equilibrium between the contribution of rivers, precipitation supply, and the inflow from the Black Sea on the one hand, and the copious evaporation and the outflow into the Black Sea and the Atlantic Ocean on the other.

THE FACE OF THE SKY FOR JUNE.

By HERBERT SADLER, F.R.A.S.

AT the time of writing these lines several fine spots and groups are visible on the solar surface. Throughout June there is no real night, but either daylight or twilight. A minimum of the Algol-type variable U Coronæ will occur at 10h. 11m. P.M. on the 20th.

Mercury is technically a morning star during the first portion of the month, but is in reality too near the Sun to be observed. He comes into superior conjunction on the 20th. Venus, during the greater portion of the month, is *the* conspicuous object in the evening sky. She attains her greatest brightness on the 4th, when she is more than three times brighter than she was on January 1st. She sets on June 1st at 11h. 14m. P.M., or 3h. 9m. after the Sun, with a northern declination of 24° 16′, and an apparent diameter of 36″, $\frac{29}{100}$ths of the disc being illuminated. On the 9th she sets at 10h. 45m. P.M., or 2h. 34m. after the Sun, with a northern declination of 22° 49′, and an apparent diameter of 40·8″, $\frac{21}{100}$ths of the disc being illuminated. The crescent form of the planet may now be easily seen in a good opera or field glass, if Venus is viewed before sunset or just after, so that her glare does not interfere with distinct vision. On the 17th she sets at 10h. 10m. P.M., or 1h. 53m. after the Sun, with a northern declination of 21° 18′, and an apparent diameter of $46\frac{1}{2}$″, about $\frac{13}{100}$ths of the disc being illuminated. On the 24th she sets at 9h. 29m. P.M., or 1h. 10m. after the Sun, with an apparent diameter of $51\frac{1}{2}$″, $\frac{7}{100}$ths only of the disc being illuminated, while her brightness has fallen to one-half of what it was on June 4th. After this date she is too near the Sun to be clearly seen. During the month she hovers on the confines of Gemini and Cancer; but does not approach any bright fixed star.

Mars is an evening star, but owing to his great southern declination is badly placed for observation in these latitudes. He sets on the 1st at 0h. 3m. A.M., with a southern declination of 20° 23′, and an apparent diameter of $14\frac{3}{4}$″, the phase on the south-western limb amounting to 1·5″, and

the light of the planet amounting to rather less than one-third of what it will be at the beginning of August. On the 17th he rises at 11h. 14m. P.M., with a southern declination of 20° 4′, and an apparent diameter of 17½″, the phase amounting to 1½″. On the 30th he rises at 10h. 34m. P.M., or 2h. 16m. after sunset, with a southern declination of 20° 26′, and an apparent diameter of 20″, the phase amounting to 1″, and the brightness to about six-tenths of what it will be at its maximum. During the month Mars describes a short direct path in Capricornus, but does not approach any bright star very closely. As Jupiter does not rise till after midnight on the last day of June, we defer an ephemeris of him till next month.

Saturn is an evening star, and is still well situated for observation. He rises on the 1st at 0h. 28m. P.M., with a northern declination of 4° 48′, and an apparent equatorial diameter of 17½″ (the major axis of the ring system being 40½″ in diameter, and the minor 0·3″). On the 30th he sets at 11h. 31m. P.M., with a northern declination of 4° 18′, and an apparent equatorial diameter of 16¾″ (the major axis of the ring system being 38·6″ in diameter, and the minor 0·7″). During the first portion of the month the ring system is invisible in small telescopes. The following phenomena of the satellites may be observed (the times are given to the nearest quarter of an hour). June 5th, 10¼h. P.M., Tethys, eclipse reappearance; June 8th, 11½h. P.M., Dione, eclipse reappearance; June 19th, 10¼h. P.M., Dione, eclipse reappearance; June 22nd, 10h. P.M., Tethys, eclipse reappearance; June 30th, 9h. P.M., Dione, eclipse reappearance. During the month Saturn describes a short direct path in Virgo, but does not approach any naked-eye star. He is in quadrature with the Sun on the 14th.

Uranus is well situated for the purposes of the amateur observer, rising as he does at 4h. 16m. P.M. on the 1st, with a southern declination of 11° 54′, and an apparent diameter of 3·7″. On the last day of the month he rises at 2h. 19m. P.M., with a southern declination of 11° 43′. During the month he describes a short retrograde path to the N.N.W. of λ Virginis. A map of the path of Uranus is given in the *English Mechanic* for February 12th. Neptune is invisible.

There are no very well marked showers of shooting stars in June.

The Moon enters her first quarter at 9h. 51m. A.M. on the 2nd; is full at 1h. 32m. P.M. on the 10th; enters her last quarter at 9h. 1m. P.M. on the 17th; and is new at 2h. 6½m. P.M. on the 24th. She is in apogee at 6·6h. P.M. on the 5th (distance from the earth 251,690 miles); and in perigee at 2·4h. P.M. on the 21st (distance from the earth 227,250 miles). Her greatest eastern libration occurs at 4h. 40m. A.M. on the 14th, and her greatest western at 3h. 54m. P.M. on the 22nd.

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

The April problem is unsolvable. The composer's intention 1. R (R8) to R6, discovered by Alpha and H. S. Brandreth, is defeated by 1 . . . P×R, as pointed out by Alpha.

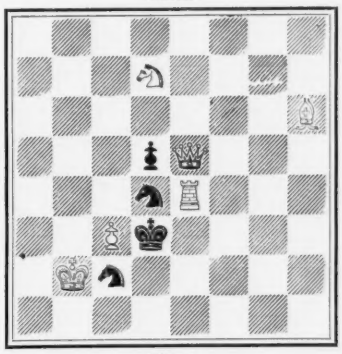
C. T. Blanshard.—The emended version enclosed is open to the same objection as the other.

C. J. O.—If 1. R to Q8ch., K×P, and there is no mate.

PROBLEM.

By C. D. LOCOCK.

BLACK.



WHITE.

White to play, and mate in two moves.

MORE CHESS FALLACIES.

(*Continued from March*, 1891.)

VI. *That the majority of Pawns on the Queen's side is advantageous.*—In the first place there is nothing magical in the Queen's side; if both players have castled on the Queen's side, then the advantage lies with the player possessing the majority of Pawns on the *King's* side. If, on the other hand, White has castled on the Queen's side and Black on the other side, Black having most Pawns on the King's side, and White on the other wing, then White has a slight advantage; for the White King at QB square can reach K3 in two moves, while the Black King at KKt square must take three moves to reach Q3. Hence the corollary that it is better for end-game purposes to castle on the Queen's wing. The King is not only more central, but almost certainly has an exit available at Q2 towards the centre.

VII. *That an early sortie of the Queen is inadvisable.*—On an open board, especially after one or two exchanges, the sooner the Queen comes out the better. If there is one strong move more habitually overlooked than any other by good players, it is probably the move *Q to KKt4*. Owing to the fact that the adverse QB and KKt generally guard against the move, the opportunities for it are necessarily of rare occurrence: the result being that when they do occur they are neglected.

VIII. *That Bishops of opposite colours always tend to a draw.*—The contrary is often the case. Imagine that Black has castled on the King's side and weakened his position by the move P to KKt3. It is now to White's advantage that each player should lose his King's Bishop, leaving the Bishops of opposite colours. The White Queen's Bishop in conjunction with the Queen and a Knight or Rook will then probably be irresistible on the King's side, White's Bishop commanding the holes at KB6 and KR6, while the Black Queen's Bishop is practically useless for defence. The general rule may be stated as follows: If your opponent has all, or nearly all, his Pawns on one colour, get rid, if possible, of his Bishop of the *other colour*. The remaining Bishop may guard some of the Pawns, but he cannot guard what is more important—the *diagonals among the Pawns*.

XUM

The following is the fourth game of a match for the Championship of America now in progress. It is understood that Mr. Steinitz does not claim the title.

[VIENNA OPENING.]

WHITE (Lipschütz).	BLACK (Showalter).
1. P to K4	1. P to K4
2. Kt to QB3	2. Kt to KB3
3. P to KKt3	3. B to K2 (*a*)
4. B to Kt2	4. Kt to B3
5. KKt to K2	5. P to Q3
6. Castles	6. B to Q2 (*b*)
7. P to Q3	7. Q to Bsq
8. B to KKt5	8. P to KR3 (*c*)
9. B × Kt	9. B × B
10. Kt to Q5	10. B to Qsq (*d*)
11. P to KB4	11. B to Kt5
12. P to B3	12. Kt to K2
13. Kt to K3	13. B × Kt
14. Q × B	14. P to QB3
40 min.	55 min.
15. P × P	15. P × P
16. Q to R5	16. Kt to Kt3 (*e*)
17. Kt to B5	17. Castles.
18. Q to Kt4 (*f*)	18. K to R2
19. R to B3	19. P to B3 (*g*)
20. P to KR4	20. R to KKtsq (*h*)
21. P to R5	21. Kt to Bsq (*i*)
22. B to R3	22. Q to B2 (*j*)
23. Kt to R4	23. Q to Kt3ch
24. R to B2	24. Q to K6
25. K to Kt2 (*k*)	25. Q × QP (*l*)
26. Kt to Kt6!	26. Q to B5
27. Q to B5	27. Resigns (*m*)

NOTES.

(*a*) A very tame reply to a not very formidable attack. A much more enterprising line of play would be 3. . . B to B4; 4. B to Kt2, P to QR3! (to preserve the Bishop), followed by Kt to B3, P to Q3, and the moment White castles P to KR4! The present annotator has adopted this counter-attack with success in more than one match-game.

(*b*) Again feeble. The Bishop should go to Kt5. If then 7. P to KB3, the Bishop retires to Q2, followed by P to KR4 soon; or if 7. P to KR3, B to K3, to be followed by Q to Q2 and P to KR4. White castled too soon.

(*c*) Waste of time. If he meant anything by his last move he should consistently play B to R6.

(*d*) This endeavour to preserve his two Bishops cramps his game terribly. He might play Kt to K2. If White take the Bishop the doubled Pawn can always be got rid of, and there is the open file for what it is worth.

(*e*) Clearly if 16. . . Q to K3, the reply 17. B to R3 wins a Pawn.

(*f*) To prevent Kt to K2, as he does not wish his Knight disturbed, and threatening also P to KR4.

(*g*) There seems to be nothing better. The position now is accidentally a good illustration of some remarks above on Bishops of opposite colours. The Black Bishop being of the same colour as the Pawns on the King's side is at a disadvantage, while the White Bishop has the advantage of being able to occupy the diagonals among these Pawns. The Bishops of opposite colours *prevent* the game being drawn.

(*h*) This and the next move leave his King and Rook shut in. Perhaps R to B2 would be better.

(*i*) Intending to fix the Knight afterwards at Kt4 if permitted. Kt to K2 seems much superior. White's reply threatens Kt × RP.

(*j*) He has not time for this diversion. 22. . . Kt to K3 is out of the question on account of 23. Q. to R6ch and 24. Kt × RP. His best course seems to be either 22. . . B to Kt3ch and 23. . . Q to Ksq, or 22. . . P to KKt3.

(*k*) Tempting the Queen to go to Kt4, whence she would have no escape: partly too on account of the threatened B to Kt3.

(*l*) If 25. . . Q to Kt4, 26. Q to K2, P to KKt3; 27. P × P, followed by B to B5 or R to B5, according to whether Black retake or not. Perhaps his best resource lay in 25. . . B to Kt3 and 26. . . R to Ksq, with a view to Kt to K3, but the game seems lost anyhow.

(*m*) For the Bishop at last will get on the diagonal with fatal effect; *vide* Note (*g*).

CHESS INTELLIGENCE.

The Scotch Championship has again fallen to Mr. D. Y. Mills, who scored 9½ games out of 11; Mr. G. E. Barbier was second, one point behind the winner.

The Committee of the World's Fair are arranging for an International Tournament at Chicago next year.

It is stated that another telegraphic match will be played this summer between Steinitz and Tschigorin—this time, probably, without restrictions as to the openings. During the course of the match, Dr. Tarrasch and M. Tschigorin will engage in a match over the board, either at Berlin or St. Petersburg. A year or two ago, M. Tschigorin's chance of success would have been considered slight, but he has had plenty of first-class practice lately, and should at any rate make a good fight against the German champion, whose opportunities for match practice are limited.

Another Divan Handicap was in progress last month. The leading scores are at present, Loman, 10; Lee, 9; and Van Vliet, 7½.

Messrs. Blackburne and Lasker commenced a match for £50 a side, at the British Chess Club, on May 23rd.

The match goes to the winner of the first six games, draws not counting. Play takes place every week day, except Wednesdays, beginning each day at 2 P.M. The time limit is 18 moves an hour.

The following is the score in the Lipschütz—Showalter match in America: Lipschütz, 4; Showalter, 1; drawn, 4.

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